UNIVERSITY OF MICHIGAN
AUG 15 1955
FORESTRY LIBRARY

IRRIGATION

WORLD CROPS

embracing

AGRONOMY, HANDLING, PROCESSING, STORAGE AND PROTECTION
SOILS, CHEMICALS, IRRIGATION, ENGINEERING AND ECONOMICS

VOLUME 7, No. 8 AUGUST 1955

A Publication of The Leonard Hill Technical Group

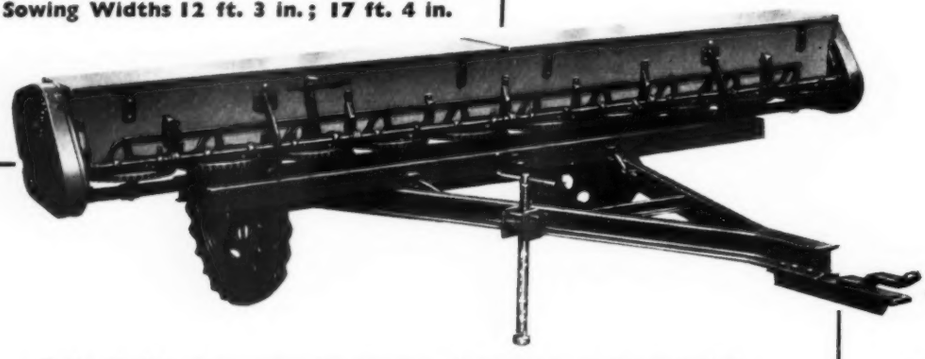
The 'Silorator' Forage Harvester cutting and loading silage in Sussex, England

WILMO FERTILISER DISTRIBUTORS

THE WORLD'S LEADING RANGE

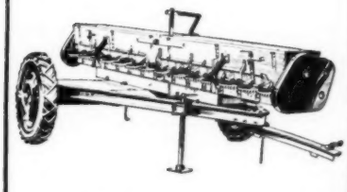
10 AND 14 DISC MODELS

Sowing Widths 12 ft. 3 in.; 17 ft. 4 in.



Both Models are compact, strong and efficient, and particularly suitable for large acreages. Large pneumatic tyres provide good flotation on soft ground. The patent feed discs and fast rotating spinner fingers ensure completely even and accurate distribution of fertilisers, insecticides and most small seeds. When the feed box is swung into the working position, additional fertiliser can be carried on the trailer platform.

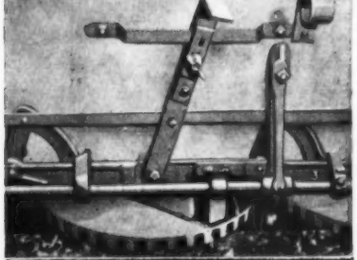
Capacities :
10 *Disc* 10 *cwt. in hopper ;* 7 *cwt. on platform.*
14 *Disc* 13 *cwt. in hopper ;* 10 *cwt. on platform.*



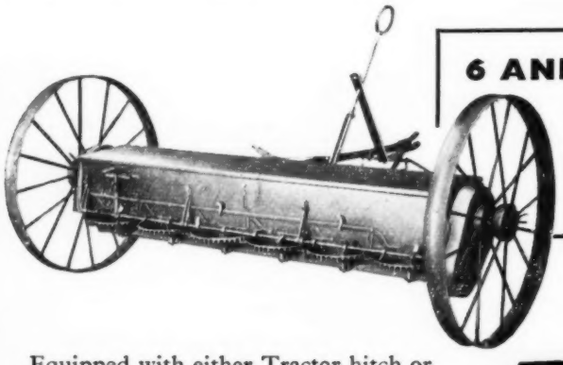
A simple jacking system on both Models allows swift conversion from field work to road transportation.

2 Leading Features on all 4 Models

No tools are needed to remove the feed discs for cleaning. Just turn a lever below the disc and it's free



A simple lever gives fine adjustment of the amount of material distributed



6 AND 7 DISC MODELS

Sowing Widths
7 ft. 4 in.
8 ft. 7 in.

Equipped with either Tractor hitch or horse shafts as required, the 6 & 7 Disc Models employ the same method of distribution as on the two larger machines. As on all Wilmo distributors the clutch controls are operated from the driver's seat. The working parts are extremely easy to clean, a feature which ensures a long working life.

Capacities :
6 *Disc* 4-9 *Bushels* · 7 *Disc* 5-7 *Bushels*

By Appointment Suppliers of Agricultural Machinery to the late King George VI.

DISTRIBUTORS

JACK OLDING & CO. LTD.

HATFIELD · HERTS

ENGLAND

Telephone: Hatfield 2333

WORLD CROPS

Vol. 7, No. 8

CONTENTS

AUGUST 1955

EDITORIAL COMMENT:
Ave et Vale; Egyptian Irrigation; Atoms for Agriculture; Italian Difficulties; Earthworm Estimates; Raining Cats and Dogs; Farm Sprayer Tanks; Fertiliser Economics; Pest Infestation Research; Background to Progress 297

Fundamentals of Irrigation—*A. W. Riddolls*, B.ECON., B.SC., A.M.I.MECH.E., M.I.B.A.E. ... 301

Spraying Techniques and Machinery in the Sudan Gezira—*A. M. Toms*, N.D.A. 306

General Irrigation Equipment—*C. S. Wright* 309

Russian Comfrey—Food for Thought—*L. D. Hills* 313

The Use of Sprinkler Irrigation Systems in Central and South America—*Deborah Gilbert* 317

Yugoslav Agriculture's Ten-Year Plan—*M. Gordon* 320

Sir Harold Tempany 325

Excessive Cultivation Can Reduce Grape Yields—*C. G. Forshey* 326

Irrigation by the Spray-Line System—*J. S. Stower* 329

Australian Agricultural News 331

South African Agricultural Developments ... 332

New Books 334

Farm Machinery 336

World Crop Reports 338

This month's cover picture shows the 'Silorator' Forage Harvester cutting, lacerating and loading silage on Baker's Farm, Shipley, near Horsham, Sussex, England.
This machine—the most versatile of its kind in the world—has revolutionised silage making. It simplifies the whole operation, cuts the cost and makes one man a team. By lacerating the crop it ensures quicker fermentation, a more evenly filled silo and better quality silage. Very little consolidation is needed and the silage has no smell whatever.

For full details write to:
SILORATORS LTD., 103 PARK STREET, LONDON W.1

Published monthly by Leonard Hill Limited, Stratford House, 9 Eden Street, London, N.W.1, England (Tel. Euston 5911)

Patron: Her Majesty The Queen

SMITHFIELD SHOW

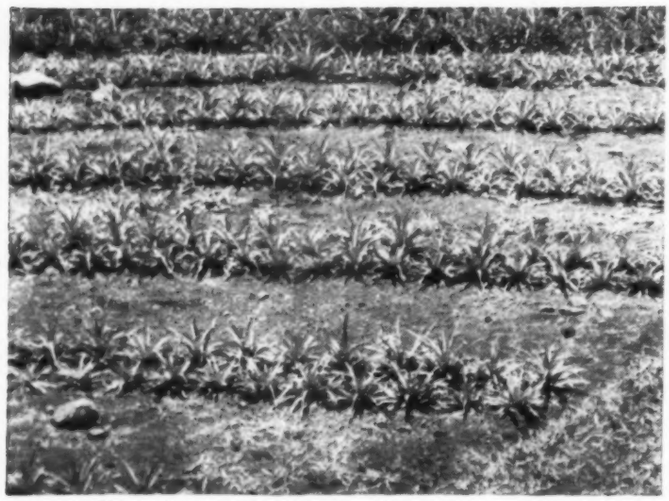
Under one roof within the vast Earls Court building, the Smithfield Show will bring to London the largest and most comprehensive agricultural show yet staged. The latest in agricultural ideas and equipment for mechanized farming will be presented alongside the leading breeds of Britain's fatstock — cattle, sheep and pigs. The extensive carcase exhibition provides a spectacle of its own and all combine in a colourful presentation to set British farming before the world.

Free facilities are available to overseas visitors.
Details from The Smithfield Show Joint Committee,
148 Piccadilly, London, W.1., England.

EARLS COURT
LONDON

5-9 DEC

Rice



Pineapples

Weed Control

cheaper and more efficient with Monsanto chemicals

Monsanto chemicals 2:4-D and PCP have proved amazingly effective for weed control in many parts of the world.

Write for full information *today !*

Sugar cane

Monsanto chemicals for treatment of weeds

- 2:4-D Sodium Salt. Hormone-type weedkiller.
- 2:4-D "50" Amine Salt. Hormone-type weedkiller, effective against nut grass and especially formulated to prevent nozzle blockage.
- Pentachlorophenol — Contact Weed Killer. To support 2:4-D and prevent 2:4-D resistant weeds from becoming dominant Monsanto's 15% PCP emulsifiable oil (containing 1½ lb. PCP per gallon) is most effective. It forms a stable emulsion (even in hard water) and is compatible with 2:4-D.
- Also available is a 25% PCP emulsifiable concentrate especially effective for the control of aquatic weeds.

MONSANTO CHEMICALS LIMITED, Victoria Station House, London, S.W.1.

MONSANTO CHEMICAL COMPANY, St. Louis, U.S.A. Monsanto Canada Ltd., Montreal. Monsanto Chemicals (Australia) Ltd., Melbourne. Monsanto Chemicals of India Ltd., Bombay. Monsanto Argentina S.A.I.C., Buenos Aires. Monsanto S.A., Mexico. Monsanto-Kasei Chemical Co., Tokyo, Japan. Monsanto-Boussois, Paris, France.

MONSANTO

Editorial Comment

Ave et vale

WE announce with deep regret the sudden death of Sir Harold Tempany, C.M.G., C.B.E., D.SC., F.R.I.C., who was, until recently, Editor of WORLD CROPS. Sir Harold was an outstanding authority on tropical agriculture and devoted much time to agricultural development in the colonies. We shall all mourn his passing.

An obituary notice appears on another page.

Egyptian irrigation

IN this issue of WORLD CROPS emphasis has been placed on some aspects of the important problem of irrigation. Several well-known technical authors have contributed articles on different phases and developments in this field of agriculture; Mr. A. W. Riddolls, Head of the Agricultural Engineering Department, Canterbury Agricultural College, N.Z., has written an interesting paper which deals with the fundamental problems. He stresses the fact that careful consideration should be given to all factors that affect efficiency and economy and that sound management practices are necessary in order to reap the fullest benefits. We hope, also, to publish, in a forthcoming issue, the results obtained by M. Georges Grillot, Chief of the Agronomic Research Service, Morocco, from his study of irrigated wheat in the French Protectorate.

Further, among the reports of the many reclamation and irrigation projects being planned in Egypt has recently come the news of a vast reclamation scheme designed to irrigate a large area of desert land on the east side of the Suez Canal. The plan is to take water from the Nile, by way of the Ismailia Canal, and siphon it under the Suez Canal to an area which, when made arable, could support some 50,000 Palestinian refugees. Citrus fruits, mangoes, dates, tomatoes, peanuts and melons could be grown in this area, which is known as the Sinai strip. A report on the scheme is shortly to be presented to the Egyptian Government by the United Nations Relief and Works Agency (U.N.R.W.A.), which has carried out detailed engineering and economic surveys with Egyptian co-operation.

The Sinai strip is an almost rainless area of desert land between the Bitter Lake and the tidal flats bordering the Mediterranean at the northern end of the Suez canal. It is about 15 miles long with an average width of three and a half miles. For the purposes of the scheme the Ismailia Canal would have to be widened at the point where it leaves the Nile north of Cairo and a branch canal would have to be dug near Ismailia to carry water to the siphon under the Suez. This inverted siphon would be more than 1,200 ft. long, its tube having a diameter of 15 ft. Construction of this siphon is expected to be difficult owing to the Suez Canal traffic, which has to pass unimpeded overhead. Channels would have to be cut on the east side of the Suez Canal to distribute the water north and south. Pumping stations would be needed and in some places the channels would have to be lined to prevent seepage. The project would be financed by U.N.R.W.A. from a special fund of $30 million.

Atoms for agriculture

AGRICULTURAL researchers in many countries are making wide and increasing use of the ' tracer ' technique with radio-isotopes to find more efficient methods of food production—to provide more food for more people. This powerful new research tool has enabled agricultural scientists to solve many problems hitherto insoluble, and has provided the means of tracing the body-building elements required by man—from the soil to the plant—through the plant—to the animal—and from the animal to man himself.

The use of fertilisers has increased agricultural production throughout the world, but once fertiliser was added to the soil it was hitherto impossible to assess how much was taken up by the plant. Now, by adding radio-active phosphorus, for example, to fertiliser, it is possible to measure with the aid of Geiger counters the amount of fertiliser actually taken up by the crop. In this way it has been discovered that, whereas plants such as maize, tobacco and sugar absorb fertiliser only in the early stages of their growth, the potato will absorb it throughout its growth. Thus we have discovered when to use fertiliser most efficiently. We have also discovered how it can best be applied. There is no need, for instance, to plough pasture in order to apply phosphorus—it will be absorbed if spread over the leaves. And we have found that it is as effective to add acid to irrigation water as it is to spread fertiliser over the soil. Such experiments will lead to saving both in fertiliser and human effort.

Important discoveries as to how and when it is best to attack certain plant diseases have been made with the aid of radio-isotopes. Radio-iodine, injected in an oak, has shown how the oak-wilt fungus travels from one tree to another—through the roots. Research with a weedkiller made radio-active has revealed that, whereas the preparation is active against broad-leaved plants within two hours, it is less effective against narrow-leaved plants.

The atom can speed the development of better types of plants. By bombarding plants with radio-active cobalt, at differing degrees of intensity, the mutation

rate can be increased and beneficial changes selected. In this way American research workers at Brookhaven have already succeeded in producing a new type of oat which is resistant to certain serious diseases.

Italian difficulties

AN account of the agricultural problem that exists in Italy was given recently by Signor Maurizio Parasassi in the *Financial Times Survey* of Italy. It was stated that a high percentage of the total labour force—42.4—is engaged in agriculture, but agricultural income accounts for only 28% of the total national income. This shows up badly against other countries for the average agricultural income in Italy today is $130 a year—less than the comparable figures for Poland, Hungary, Austria and Norway, and greater only than those of Bulgaria, Finland and Rumania.

With the improvement in the Italian standard of living, recorded in statistics of the national income, food consumption has, as with countries with higher national incomes, tended to rise. On the other hand, cereal consumption has gone down and consumption of vegetables and dairy products has risen.

At present the cost of agricultural machinery is comparatively low because of the effective competition in the industry, but if mechanisation is an essential condition of agricultural progress, the drawback is that it makes redundant a mass of labour that cannot be absorbed in other activities.

Italian farmers acquired 26,000 tractors (23% increase) in 1954. Fertiliser consumption has extended and last year the consumption of nitrogen fertilisers increased by 23.7% and phosphates by about 50%. However, consumption still remains extremely low, but this is accounted for by the fact that much of Italy is mountainous and it does not allow the same high rate in the use of fertilisers as is the case with flat countries. Also, losses due to rain and errosion raise the cost to an uneconomical level.

With regard to organisation, agriculture in Italy has not made the progress that high exports of fruit and distribution for internal consumption would call for. This failing is blamed on the existing division of agricultural properties into small units which does not allow economic rationalisation.

It is well known that the most important agricultural problem that the various post-war Governments have been called on to face concerns productivity. In particular, problems have concerned the absorption of agricultural labourers into other jobs, formation of small and medium-sized properties, and the provision of agricultural education. Legislation has been directed recently to these objectives: agrarian reform, with a twelve-year plan for agricultural developments, productivity competitions, with assistance for the acquisition of agricultural machinery.

Earthworm estimates

GRASSLAND research in New Zealand (R. A. S. Waters, *N.Z. Journal of Science & Technology*, 1955 [A] **36**, 516) places a rather stronger emphasis upon the place of earthworms in pasture. Measurements of earthworm population have certainly given very different results from those of other modern investigations. Worm numbers in the New Zealand research were estimated at between 3 and 5 millions per acre compared with figures between 450,000 and 750,000 per acre for English and American studies. Admittedly the New Zealand pasture chosen was one of particularly high productivity but the order of difference—fivefold to tenfold—is very large. The method of measurement used in New Zealand, the monthly removal of random plugs of soil to a depth of 1 ft., may well have been more accurate than relying, as in the 1947 Rothamsted experiments, upon a count of worms expelled by applying potassium permanganate solution. The New Zealand variation from 3 to 5 millions per acre mainly reflects seasonal change in population; the actual weights of worms per acre were assessed at 1,300 to 2,700 lb. The peak, as in this country, is reached in the autumn.

Opinion varies somewhat controversially as to the importance of earthworms' contribution to soil fertility, but with pasture-land the single factor of aeration must have significant value. Other New Zealand work has indicated that worms do not feed upon living plant matter including living roots; their diet is based upon dead plant debris. It is suggested that the autumnal peak in numbers is due to the peak in production of plant debris, particularly root debris. Worms can also feed upon animal manure, but it seems doubtful if this is a major source of food for them; if it were, the sharp seasonal variations in population on *grazed* pastures are difficult to explain.

There is another influence that may well account for these high population figures reported from New Zealand, although it is not mentioned in the paper itself. New Zealand grassland is based upon the grass-clovers association, and it is possible that conditions that favour clover growth also favour earthworms, *e.g.* the special attention given to lime and phosphate supply. It is already known that some kinds of nitrogenous fertiliser tend to discourage earthworms.

Raining cats and dogs

FOLLOWING the article on rain-making in Australia (WORLD CROPS, **7**, 284, 1955) our attention has been drawn to a recent letter in an English national newspaper. It asked if it would be possible for the Air Ministry to carry out their rain-making experiments over the Atlantic instead of over the Salisbury Plain

area. Quoting a spokesman as saying that ' The crystals (silver iodide) will be blown miles away by the wind and we shall have to determine which area they will reach after looking at the winds ', the correspondent said, somewhat pathetically, that he happened to be having an evening garden party about 50 miles north-east of the Plain and could he, therefore, make a humble application for no crystals in his area on that day. ' Later on ', he added, ' I shall be obliged if the Air Ministry will keep their crystals in the box while I am continuing my harvest '.

It is obvious that the Air Ministry must give very careful consideration to this request, for if they accede to it they will be setting up what is known in legal circles as a precedent, and they will doubtless be inundated with many more similar applications. The difficulty will be in deciding where to draw the line, for each case would have to be examined on its own merits.

Conducting the experiments over the Atlantic, however, may not solve the Air Ministry's problems. The number of applications from travel agencies for the Air Ministry to ' keep their crystals in the box ' would be staggering.

Nevertheless, a *Financial Times* correspondent writes: ' Farmers and residents in the district have been given a guarantee that there will be no increase in the number of rainy days as a result '. The biggest doubt of the value of cloud seeding lies in the problem of whether seeded clouds would have produced rain naturally in any case.

Farm sprayer tanks

IN a recent American survey of the effects of agricultural chemicals on application equipment it was found that the tanks of spraying machines are the commonest source of complaint. This does not necessarily mean that chemicals frequently corrode right through the tank wall, rather is it that the nuisance value of a sprayer tank can be high; gradual accumulation of scale in the tank may be carried through the spraying system, plugging nozzles and abrading pumps.

What is being done to rectify this so-called nuisance value? Spraying machine manufacturers are turning their attention to the many protective coatings available today for use on interior tank walls. New materials of construction other than steel, such as metal alloys and glass-fibre laminates, are being tried out and experimental cathodic protection of steel tanks is being investigated. In the laboratory, evaluation of the corrosiveness of insecticides, fungicides, weed-killing chemicals, etc., is under way, so that now chemical manufacturers can tell the equipment makers pretty accurately just what effects any particular chemical is likely to have on any particular fabrication material.

Of course, while uncoated steel tanks continue to be made—and from the price factor alone this will be for many years yet—a lot depends on the good sense of the user. If such precautions as draining the tank after use, rinsing with clean water, and coating with oil when laying up are not taken, then the farmer may be courting trouble. On the spraying equipment manufacturers' side, sprayer design should be such that cleaning and complete draining are as easy as possible.

These investigations into the effect of spray chemicals on application equipment are being jointly financed by such interested bodies as the Power Sprayer Division of the Farm Equipment Institute, the National Sprayer and Duster Association, the National Agricultural Chemicals Association and the U.S. Department of Agriculture Research Service. This is typical of the sort of co-operation which makes for improvements in this industry and could well be emulated in many other fields.

Fertiliser economics

IN America and Britain farmers now order their fertilisers when they want to use them—any tendency to spread deliveries over a number of months is minute. A local agent's comment this spring in the U.S.A. is centred on the target: ' The farmer knows that the stuff is there and he can get it when he wants it '. What this means for factories and merchants still seems seriously under-appreciated. The spring season in any particular region is today a fairly narrow period for mechanisation has enabled large daily acreages to be combine-drilled; in about one-tenth or at the most one-sixth of the year, three-quarters of the annual usage of fertiliser is applied to farm soils. If this huge proportion of annual production has to be transported to farms within the same short period, the ' rush-hour ' problem created is unequalled in any other important industry. The sudden and short-term demand upon rail waggons, lorries, factory loading gangs etc. might be comfortably met in times of trade depression and unemployment but these are not the background conditions of industry today. The plain truth is that storage facilities on farms and in fertiliser factories have not kept pace with the increase in usage and output.

There is small doubt, however, that many farms could take in at least a part of their annual fertiliser requirements some months before use. The American industry seems to have very little faith in price inducements for encouraging farmers to do this; few firms offer early delivery rebates and those that are offered are small. In this country the method of price inducement has been more persistently tried, and it is surprising that so few farmers take advantage of it. In the spring issue of *Farm Management Notes* (University of Nottingham School of Agriculture), Mr. R. Bennett

Jones points out that the average 20 tons per 100 acres used each year by Midland farms would cost farmers nearly 20% less if they accepted delivery in August and also paid cash to avoid charges for credit. On 1954/55 prices for a typical compound, the cost of 20 tons sold in the spring on credit amounts to £357 10s. The cost in August, with payment within 28 days, is £292 10s. Saving—£65. This is not a negligible sum. 'The time to look for capital is before a debt is incurred, not afterwards . . . £300 borrowed to ensure a saving of £65 a year on fertilisers could be repaid in six years and few farmers would need to borrow the whole amount . . .'

Farm storage that is exposed to the weather is not suitable, of course, but modern granulated fertilisers in moisture-proof multi-wall bags can be safely stored under average farm-building conditions. Some farmers have successfully stored up to 18 tons in the open in thatched clamps. Perhaps there would be a stronger inclination to take earlier fertiliser deliveries if the amount of saving on costs was more widely realised.

Pest infestation research

THE announcement that the background of work carried out at the Pest Infestation Laboratory is changing comes as no surprise. The early work of the laboratory, which was set up in 1940, was directed towards the solution of war-time problems, particularly the conservation of large stocks of cereals in an insect-free condition. These problems have increased in variety, but the protection and treatment of bulk cereals has remained an important part of the research programme up to the present time. The almost complete cessation of Government ownership and bulk purchase of foodstuffs, however, makes it extremely likely that the quantity of grain and other foodstuffs held in store in the country will decrease, with the result that there may be a relatively rapid turnover of commodities. Such changes in food-handling policy would bring certain infestation problems into greater prominence and others would become of less immediate importance in this country.

In their annual report, 'Pest Infestation Research, 1954', the Pest Infestation Research Board state that it should be possible for the laboratory to keep abreast of new problems arising from changing conditions without disturbance of long-term research on the disinfestation and protection of particular foodstuffs, particularly of grain held in bulk storage. The Research Board give two reasons why they consider that this field of research is important. Firstly, it is impossible in this country to forecast whether a sudden change of circumstances might arise and which might necessitate the storage of food on a large scale over long periods; in this event it would be essential to have the most complete background of relevant scientific knowledge. Secondly, many countries in the Colonial Empire and the Commonwealth are becoming increasingly concerned with bulk storage of cereals over long periods, for famine reserves or other purposes. Although the background of information now available in the laboratory is proving of great value in this field, new problems or variations of existing problems are clearly demonstrating the need for a continuation of research on this subject.

Background to progress

IN every technology the foundation of advancement is education; not merely the specialised education of a few leaders, but the general education of the many. It is not often pointed out that farming can be handicapped by the fact that educational facilities are often limited by the remote and spacious isolation of rural areas. In small and close-woven countries like Britain this problem is relatively small and not difficult to overcome even in its worst examples; it is much more formidable a problem in large countries. Some interesting figures on this subject were recently published by the U.S. Information Service. Until recently the Education of the U.S. agricultural population has lagged behind the national average. Older workers grew up at a time when farming was less complex, and the shortest and most elementary period of schooling was all that they considered necessary. In any case, transport for taking children to secondary schools was frequently unavailable.

The present position is far better. Only one-sixth of the farm population aged between 70 and 74 had attended a secondary school for as short a period as one year; but in the age-group between 20 and 24 six out of every 10 were at a secondary school for one year or more. Ignoring grades of education, the total length of school attendance has steadily improved. The present 20-24 age-group averages 10½ years of schooling; the 45-49 age-group averages eight and a half years, whereas the 70-74 age-group shows an average of only seven and a half years. Farmers themselves realise that their children must have a better education to cope with the technicalities of modern methods. Of the present-day American farmers whose annual sales exceed $5,000, more than half had been to secondary schools and less than a quarter had received elementary education only.

Nevertheless, it is far from easy to maintain, let alone to increase, this rate of improvement. Estimates have shown that today's school population in farming areas of 11,700,000 will have risen to more than 15 millions in a mere five years' time. The demand for larger school facilities and more teachers will be difficult to satisfy even from America's great resources.

Showing irrigation canal to develop sheep country near Ashburton, Canterbury Plains. Note the well-planned layout of the fields and pastures

Fundamentals of Irrigation

A. W. RIDDOLLS, B.ECON., B.SC., A.M.I.MECH.E., M.I.B.A.E.

Head of the Agricultural Engineering Department, Canterbury Agricultural College, Lincoln, Christchurch, New Zealand

This article was written primarily for New Zealand irrigation farmers, many of whom are fairly new to irrigation and have little scientific knowledge of the subject, but Mr. Riddolls presents a lucid account of the subject and it should be of great interest and benefit to many of our readers.

IN most parts of New Zealand the moisture in the soil is deficient during some part of the growing season—that is, the soil moisture is less than is necessary for the maximum growth of crops and pastures—and therefore production suffers. An obvious way, then, to increase production is to apply water to the soil artificially by irrigation at times when soil moisture is tending to become deficient. But this can only be done at a price; so that, in places where soil moisture is only occasionally and irregularly deficient, the costs of irrigation will often exceed the value of the increased return from the irrigation, *i.e.* irrigation will be uneconomical. On the other hand, in places where soil moisture is deficient fairly frequently and for fairly long periods, then irrigation can be made to pay, if, in deciding on and planning an irrigation system, careful consideration is given to all the factors that affect efficiency and costs, and if sound management practices are followed.

Source of water

In the main areas of New Zealand where irrigation is practised, namely, mid-Canterbury and Central Otago, water is brought to the farm in canals and races under community schemes. The farmer who wishes to irrigate buys the water from the authority controlling the scheme, or pays rates for the privilege of using the water.

Rivers or streams flowing near or through the farm are another common source of water for irrigation throughout the country. Small streams often carry less water than they appear to, and the discharge or flow should be measured to make sure it is adequate for the job. There is also danger of their drying up in a very dry summer when the water is most needed. Before arranging to take the water from a river or stream for irrigation the authority controlling the stream must be consulted, and the rights to the water of persons lower down the stream must be respected.

Underground water is another common source of supply of irrigation water. This can be tapped by sinking wells, which can be either pipes sunk into the ground or open wells of large diameter lined with timber, steel or precast concrete. Wells in alluvial sands and gravels usually provide the best supplies. Artesian wells or springs rising naturally to the surface sometimes provide a good supply. Where the water does not rise of its own accord, a properly planned pumping installation will be needed.

For information on the possibilities of obtaining an adequate supply of water, a geologist or a well-sinking contractor experienced in the district should be consulted. No reliance should be placed on so-called ' water diviners ' or ' dowsers '.

Another possible source of water is surface run-off of rain, which can be trapped in a depression dammed by an earth dam, or in an excavated basin, in the same manner as is often done for stock water; but it must be realised that very large amounts of water will need to be stored for irrigation. For

example, to irrigate 10 acres with a depth of 18 in. of water during the season would require as much water as could be stored in a pond two acres in area and 8 ft. deep.

Highly saline water is harmful to growth. This could occur in brackish creeks and in rivers or wells in arid areas. In cases of doubt a sample of the water should be analysed.

Soils suitable for irrigation

Almost any soil can be irrigated successfully and even poor, infertile, stony soils have given good results, provided correct management and fertilising practices are followed. Shallow top soils on clay-pan subsoils should be irrigated with care to avoid waterlogging, as also should areas with a naturally high water table. Light sandy soils are difficult to irrigate by surface methods and may be inclined to erode.

Measurement of irrigation water

The depth of water applied during irrigation is measured, like rainfall, in inches. Thus we may speak of a single irrigation application of 2 in., or a seasonal irrigation of 22 in.

Volumes of water applied during irrigation are usually measured in acre-inches. One acre-inch is the volume of water that would cover 1 acre of ground to a depth of 1 in. A simple calculation shows that 1 acre-inch is equal to about 22,600 gal.

To obtain in acre-inches the volume of water applied during irrigation a simple calculation is required, *e.g.* if 10 acres is irrigated with a 2-in. application, obviously the volume applied is 10 acres $\times$ 2 in. = 20 acre-inches.

On the other hand, if a volume of, say, 60 acre-inches is applied to 40 acres of land, the average depth of irrigation water applied is 60 acre-inches $\div$ 40 acres = $1\frac{1}{2}$ in.

The flow of a stream of water, often called the ' discharge ' of the stream, either in a pipe or open channel, may be expressed in gallons per minute for small streams, such as are used for sprinkler irrigation; but for large streams suitable for surface irrigation the unit is usually 1 cusec, *i.e.* 1 cu. ft. per second. But 1 cu. ft. equals $6\frac{1}{4}$ gal., so 1 cusec is equal to 375 gal. per minute.

A very important relationship is that connecting the discharge or flow of a stream with the number of acre-inches of water delivered by the stream. An easily remembered rule is as follows: ' One cusec for one hour equals 1 acre-inch '. This means that, if a stream delivers 1 cusec or 375 gal. per minute for one hour on to a piece of land, it will apply 1 acre-inch. Thus, if a stream carrying 8 cusecs runs for two hours, it will apply 16 acre-inches; and if the area of land it runs on to is 12 acres, the average depth applied will be 16 $\div$ 12 = $1\frac{1}{3}$ in.

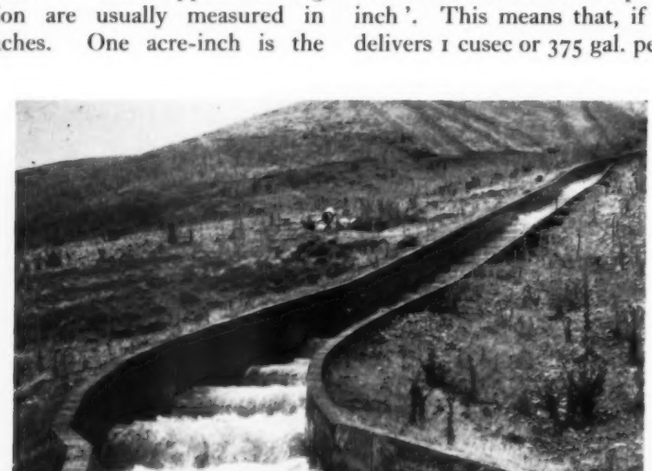
These relationships are embodied in the following useful formulae: 1. For large streams where discharge is expressed in cusecs, depth of water applied in inches = (discharge of stream in cusecs $\times$ time of application in hours)/(area in acres). 2. For small streams and discharges from small pipes and sprinklers whose discharge is expressed in gal. per minute, depth of water applied in inches = (discharge of stream in gal. per minute $\times$ time of application in hours)/(area in acres $\times$ 375).

It should be remembered that the depth given above is an average depth of application and is not necessarily uniform over the whole area. The degree of uniformity will depend on the method by which the water is applied. Losses by run-off or evaporation may reduce the depth of water actually entering the soil.

In order to know how much water is being applied to the land it is necessary to know the discharge of the stream or pipeline delivering the irrigation water.

Discharge

A rough approximation of the discharge of a stream, sufficiently accurate for estimating in preliminary investigations to see if there is sufficient water for irrigation, can be made as follows: Choose a fairly straight uniform reach of the stream and, by measuring the average width and depth of the water flow at any cross-section, calculate the area of cross-section of the stream in square feet. Then, by measuring how long a float takes to travel, say, 50 ft. along the stream, calculate the velocity of flow. Multiply the area of cross-section by the velocity, and thus obtain the discharge in cusecs, *e.g.* the average width of a stream is 3 ft. and the average depth 2 ft., therefore the area of cross-section is 3 ft. $\times$ 2 ft. equals 6 sq. ft. The float takes 25 seconds to travel 50 ft., therefore the velocity of the stream is 2 ft. per second. Then the discharge of the stream must be 6 sq. ft. $\times$ 2 ft. per second, which is equal to 12 cusecs. Of course, the



Close-up of the water stairway, Chatter Creek irrigation scheme, near Clyde, Central Otago. Water is carried 13 miles by flume and water-race to farming and fruit-growing areas

Bipod pole dams to control streams. This method consists of tying poles with a log base to prevent scouring. Wire-netting prevents driftwood

above results can only be approximate. More accurate measurements of discharge of the stream must be made when it comes to estimating how long to apply the water to the land to give a desired depth of application. To measure the discharge accurately, some accurate form of measuring device or water-meter is installed in the stream. The simplest device is a measuring weir, with either a rectangular or V-shaped notch through which the water flows. With a properly installed weir, all that needs to be done to find the discharge accurately is to measure the depth of flow above the crest of the weir. Reference to a weir table or graph will then give immediately the discharge for that particular depth.

Discharge of water from pipelines or nozzles is usually estimated by reference to details of pump discharges and pressures supplied by the pump maker, but for small flows direct measurement of discharge in a bucket or drum can be made.

Methods of irrigation

There are two main systems of irrigation, 'surface irrigation' and 'sprinkler irrigation '.

In ' surface irrigation ', sometimes called ' gravity irrigation ' or ' flood irrigation ', the water is applied to the land to be irrigated by causing it to run by gravity over the surface of the soil. Various methods are used to control the water and thus to apply the correct amount, ranging from methods that give excellent control, such as confining the water between low banks or dikes, to those inefficient methods in which water is run on indiscriminately from irregularly placed ditches that are made to overflow.

In ' sprinkler irrigation ' the water is projected into the air under pressure through one or more sprinkling devices, of which the ordinary lawn sprinkler is probably the best known example. It falls on to the ground to be irrigated in fairly small droplets. ' Sprinkler irrigation ' is sometimes called ' spray irrigation ' or ' overhead irrigation '. Both these latter terms are confusing and unnecessary.

Sprinkler or surface irrigation

Until about 40 years ago irrigation was all done by surface methods. At about that time sprinkler irrigation was invented, and during recent years, the development of readily portable equipment, such as aluminium-alloy pipe, has led to a rapid rise in popularity of sprinkler irrigation throughout the world. Nevertheless, sprinkler irrigation still provides only a very small proportion of the world's irrigation.

In spite of claims to the contrary, sprinkler irrigation is not a rival of nor a substitute for surface irrigation. It is rather an extremely useful and valuable method where irrigation would not otherwise be practicable because the soil, crop and ground surface conditions are unsuitable for surface irrigation, or where only relatively small water supplies are available. This view is supported by the world's leading independent authorities on irrigation. For example, in the words of M. R. Lewis, of the U.S. Bureau of Reclamation, ' Where conditions are favourable for surface methods, in general, surface methods are more economical in labour and money and may be equally economical in use of water. Where conditions do not favour surface methods, sprinkling may be more economical in labour, money and water. In any case, each

General view of the Earnscleugh Flats, Central Otago, showing the transformation, due to irrigation, from desert to the rich fruit-growing district of today

farm unit must be studied on its individual merits '.

There is room for wide development of both surface and sprinkler methods in New Zealand.

Irrigation and soil-moisture relationships

Crops grow best, and therefore produce most, when there is enough, but not too much, water in the soil. The purpose of irrigation should, therefore, be to ensure that there is enough, but not too much, water in the range of depth of the soil from which the roots of the plants procure water. So the fundamental question in irrigation is, therefore, how much is ' enough water '?

To answer this question let us assume as a starting point that we have in a field under irrigation soil that at the moment is fully saturated, so that all the pore spaces in the soil are filled with water throughout the whole depth of the soil through which the roots are found. This condition could occur following very heavy rain or a heavy application of irrigation water. If this condition is prolonged, most useful plants will fail to grow and will rapidly die. That is, there is *more* than ' enough water ' in the soil; there is far too much. However, if a soil has good natural drainage below, the surplus water that fills the pore spaces will soon drain out until the amount of water in the soil will have been reduced to 'field moisture capacity '. Capillary attraction will then prevent the remaining moisture from draining out. But this remaining moisture that is held by capillary attraction, called ' capillary moisture ', is capable of being used by the plants as they grow and is, indeed, the medium through which the plant roots obtain food from the soil. If no more water is applied the plants will use this capillary moisture by transpiration and some will be evaporated direct from the upper layers of the soil; the amount of moisture in the soil will be gradually depleted until the plants cannot take any more from the soil. When this stage is reached, the plants will wilt and cease to grow. The amount of moisture at which this occurs is known as the ' wilting point ' of the soil. The ' wilting point ' is, like ' field moisture capacity ', a most important level of soil moisture. It measures the upper limit of water that is held too firmly to be used by plants. In fact, for the plants to grow satisfactorily the amount of moisture in the soil should lie in the range between wilting point and field moisture capacity. This is the range that soil scientists call ' available soil moisture '.

For most crops growth rate is very much retarded when the available moisture becomes so depleted that soil moisture approaches closely to wilting point. There is much difference of opinion and conflict of evidence on the extent to which depletion of available moisture can be allowed to go without seriously affecting crop yield for various crops. For pasture, it appears probable that, for maximum yield, moisture should be kept in the upper range of available moisture, but for orchard trees yield may not be adversely affected until moisture content approaches closely to wilting point. However, practical considerations usually make it impossible to apply water continuously or frequently enough to maintain moisture at, or nearly at, field capacity; therefore, as a practical guide to irrigation procedure, until more specific information is available on specific crops, it is probably wise and safe to assume that there is ' enough water ' in the soil as long as soil moisture has not been depleted by more than two-thirds of its volume. Within the range of the upper two-thirds of available soil moisture growth will probably be at or reasonably near to maximum.

Under this system the soil moisture throughout the rooting zone of the crop would never be allowed to fall so near to wilting point that the available soil moisture had been depleted by more than two-thirds, nor to rise, except for brief periods immediately following rain or irrigation, above the upper limit of available soil moisture, *i.e.* above field moisture capacity. Thus irrigation should begin before the available soil moisture has been depleted by more than two-thirds, and sufficient irrigation water should be added to bring it up to field moisture capacity again. Then, when evaporation and transpiration had again depleted the available moisture by two-thirds, another irrigation would then restore it to field moisture capacity. A similar system is commonly used for scheduling applications of irrigation water in the U.S.A., where, due to water shortage, irrigation is practised most scientifically. The system provides the key to the amount of irrigation water to be applied at each irrigation, and to the desirable interval between irrigations.

Depth of water to be applied

It will be seen that under this system of irrigation, at each irrigation sufficient water would be applied to supply two-thirds of the available soil moisture capacity throughout the depth of soil in which the roots of the plants are effective in using soil moisture. For example, if analysis of a certain soil shows that its available soil moisture capacity is 1½ in. of water for each foot of depth of the soil, and the effective rooting depth of the crop is

2 ft., then allowing 1½ in. of water for each foot of soil, the total available soil moisture is 3 in. Assuming that irrigation is done when it should be, *i.e.* when the evaporation and transpiration have caused available soil moisture to be depleted by two-thirds, then two-thirds of 3 in., *i.e.* 2 in., of water would be needed to bring the soil up to its field moisture capacity. If appreciably more water than this is applied, it will be wasted in deep drainage or will cause waterlogging.

The available soil moisture capacity depends on the nature of the soil, and soil with a high clay content or high in decomposed organic matter will hold more available moisture than more open, sandy soils. So the depth of water to be applied at each irrigation depends on the nature of the soil and on the rooting habits of the crop.

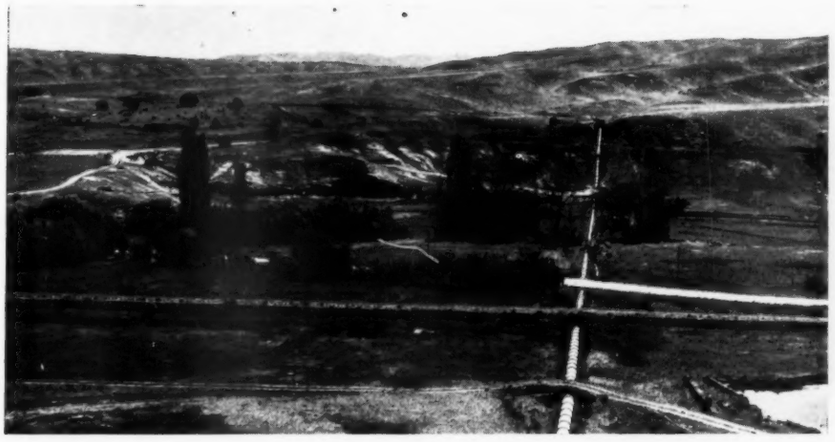
Interval between irrigation

Obviously the more available soil moisture that a soil can hold the longer it will be before irrigation has to be repeated. Thus soils with high clay content or high in decomposed organic matter require less frequent irrigation than do sandy soils, assuming, of course, that each irrigation is sufficient to fill the available soil moisture capacity. Similarly, plants with a deep-rooting system will need less frequent irrigations than shallow-rooting plants, because they can draw on a greater depth of available soil moisture.

But the rate of loss of water by evaporation from the surface of the soil and by transpiration by the plants also has much to do with the interval between irrigations. Thus in hot, dry, windy weather water will be used more quickly than in cool, humid, calm weather and irrigation will need to be more frequent under the former conditions. Similarly, some crops are capable of removing water from the soil more rapidly than others, and thus need more frequent irrigation.

Thus, whereas depth of water applied at each irrigation is a function of the soil and the rooting characteristics of the plant, ' frequency ' or interval between irrigations is a function of the foregoing and also of the climate and the water-using characteristics of the plants.

As a consequence of this, whereas a typical irrigation schedule for a shallow-rooting crop, such as lettuces, on a sandy soil might be ½ in. of water applied every five or six days in the same climatic conditions, a deep-rooted crop like lucerne on a heavy soil might require irrigation of 4 in. applied every three weeks. In particularly hot dry weather these intervals between irrigation may have to be shortened.



Chatto Creek Siphon, Central Otago, carries the water from one side of the valley to the other and under the main road. Pipes, 3 ft. 6 in. in diameter, rubber sealed, form a siphon 1,800 ft. long with a drop of approximately 200 ft. and have a capacity of 90 cusecs

Practical factors affecting water application

Even though he may understand these fundamentals of 'irrigation need', it is not easy for the irrigator to determine in practice how much water to apply and how often. Methods used by scientists are not at present available to the irrigator. Probably at present, until detailed scientific advice on irrigation need is available to the irrigator, the best guide as to whether he is putting on enough water at the right time is to take soil samples at several depths before and after irrigation, with a spade or preferably a soil auger, and to judge its moisture content by feel and appearance. Experience in this way, and observation of the state and rate of growth of the crop, will help him to determine whether or not he is observing a sound irrigation schedule. Too heavy an application of water will be wasteful and can be harmful. Too light an application will require the irrigation to be repeated sooner than necessary, and this will be wasteful of labour. Too frequent irrigation can also be harmful and waste water and labour, whereas too infrequent irrigation will reduce yields.

Of course, many practical factors may make departure from the ideal schedule unavoidable. For example, in a public scheme water may not always be available when it is needed. But, in spite of these factors, the ideal of irrigating according to available soil moisture capacity and rate of water-use should be adhered to as closely as possible.

Irrigation and drainage

The best results are obtained from irrigation if the drainage is naturally good. Where drainage is naturally poor, great care must be taken to avoid excessive applications, particularly on clay-pan soils. For best results from irrigation it may be advisable to install a drainage system on the irrigated areas, then excess water will drain away without damaging the irrigated area by waterlogging, or the land at a lower elevation by seepage.

Photos: High Commissioner for New Zealand.

Technical News

Food Manufacture for August contains ' Processed Foods from Jamaica —New Standards Devised', by L. H. Greenwood-Barton; ' Food Research at Leatherhead '; and ' Institute of Food Technology Abstracts'.

The August issue of *Dairy Engineering* contains ' Dairy Development in Cyprus—1,' by T. C. D. Atkinson, A.M.INST.B.E.; ' Flavoured Milk—Some Technical and Legal Aspects', by R. Harold Morgan, M.SC., F.R.I.C.; and ' The True Flavour of Milk'.

Spraying Techniques and Machinery in the Sudan Gezira—I

A. M. TOMS, N.D.A.

Spraying Officer, Sudan Gezira Board

Much work has been done in recent years to establish the optimum conditions and methods for control of pests on cotton grown in the Sudan Gezira. A new approach has been suggested in applying low-volume sprays by medium of aircraft. Mr. Toms has recently returned to the Sudan to take up again his duties with the Gezira Board; he is one of the few Englishmen to be retained by the Board.

THE Sudan Gezira scheme is as near to being the spraying operator's ideal as it is possible to obtain anywhere in the world. Water supply is plentiful and adjacent to all the cotton fields, the land is level, the fields are large, the crop is evenly spaced and there is only the very occasional fall of rain during the spraying season.

For the purposes of this article it is necessary to say that the Gezira scheme annually grows approximately 235,000 feddans (1 feddan = 1.038 acres or 0.42 hectare) of cotton, which is irrigated by gravity through a system of canals from the Sennar Dam. Each cotton field or *number* is typically 90 feddans, rectangular in shape and divided into nine *hawashas* or holdings each of 10 feddans. Each hawasha is normally cultivated by one tenant, the tenants being joint partners in the scheme.

The cotton is grown on the ridge and each number is irrigated by means of a large channel (*abu eshrein*) from the canal. Each hawasha has a small channel (*abu sita*) taking off from the abu eshrein, and within the hawasha and running at right angles to the ridges are small ditches (*gadwalls*) and ridges (*tagnets*), which enable irrigation to be carried out efficiently.

For the purposes of administration the whole scheme is divided into blocks varying in size from 2,500 to 9,000 feddans of cotton. The rotation is eight-course, but essentially it means that one-quarter of the total area is annually planted with cotton. This means that the cotton numbers are not continuous and are rarely adjacent. During October, the month in which the spraying is concentrated, the cotton is irrigated approximately every 14 days. The soil requires approximately 10 days after watering commences until it is dry enough for a tractor to travel on it. This is the chief drawback to the ideal spraying conditions mentioned above, as it means that the whole spraying programme requires considerable organisation within a block and that tractor spraying machines often have to travel considerable distances during a day, as it is essential that the irrigation programme is not upset.

History of spraying in the Gezira

The cotton jassid had long been recognised as a serious insect pest in the Gezira, but, owing to the absence of both efficient insecticides and application machinery, control measures were delayed until 1945. Then the cessation of hostilities and the advent of DDT plus efficient spraying contractors with suitable machinery stimulated interest in practical methods for controlling this pest. In 1945 Pest Control Ltd. sent a research team and suitable machinery to the Sudan Gezira and sprayed an area of approximately 1,500 feddans with DDT.

The excellent results obtained have been fully described by Cowland and Edwards[1] and Snow and Taylor[2] and do not require elaboration here. It is sufficient to state that the area sprayed increased every year until in 1952 some 232,000 feddans, or 98% of the cotton area in the Gezira, was treated. There is no doubt that one of the reasons why this treatment is so effective is that 1 lb. of DDT per feddan remains toxic to jassids for more than 30 days, thus giving protection during the critical period of the plant's life and when the jassids are greatest in numbers.

It was soon apparent that the early spraying techniques, which were all by land machine with down-pipes, at 100 gal. per feddan, required modification to (*a*) reduce the cost of spraying and (*b*) increase the speed of spraying, which not only assisted the cost, but also enabled the bulk of the area to be sprayed near to the optimum date or at least during the month of October. Thus, in 1948, helicopters were first used, followed in 1950 by fixed-wing aircraft, and in the same year the volume used by land machines was reduced to 50 gal. per feddan. This reduction in volume, with corresponding reduction in application costs, has continued until the present day, when the aircraft operate at either 1½ or 2 gal. per feddan and land machines between 16 and 5 gal. per feddan.

It has only been within the past two years that much thought has been given to the quantity of chemical per feddan, but it has become obvious that the biggest saving in spraying costs can now be effected by a reduction in the quantity of chemical. Application costs are now probably as low as they can be without a reduction in efficiency, whereas a reduction in the quantity of DDT from 1 lb. per feddan to ½ lb. per feddan will produce a saving of approximately 3s. 6d. per feddan. The desirability of this from a biological point is mentioned below, but it appears possible that it is both finan-

cially and biologically beneficial to apply a very minimum dose of insecticide.

Aircraft spraying

The first aircraft used for spraying cotton in the Gezira were helicopters in 1948. They sprayed on a very definite swathe width from the spray boom attached to the helicopter and were therefore purely an air-borne land machine. The spray was assisted into the crop by the downward draught from the helicopter's rotor and excellent results were obtained with volumes as low as 3 gal. per feddan.

It was found, however, that helicopters are very expensive to operate; their initial cost is high and the speed of the operation lower than by fixed-wing aircraft. Fixed-wing aircraft were tried, namely Austers, and it was proved that they were satisfactory for the work and operational costs were, on the whole, much lower.

The fixed-wing aircraft sprays from a comparatively short spray boom (20 ft.), but the spray is carried from the slipstream into the wing tip vortices, thus increasing the swathe width to 20 m. when flying at 8-10 ft. above the crop. By this method a standard volume of 3 gal. per feddan was found satisfactory and following experimentation this has been reduced to 2 and 1½ gal. per feddan by the contractors concerned.

An Auster aircraft with a tank capacity of 45 gal. and a swathe width of 20 m. takes on an average 14 minutes to spray a load, including filling time. Of this time, four minutes is actually spent over the field either spraying or turning and 10 minutes in returning to the landing strip, refilling and returning to the field. Of the four minutes spent over the field, two and a half minutes is actual spraying time and one and a half minutes turning time.

TABLE 1

From fill to fill ..	30 min.
Time over the field ..	20 min.
Time actually spraying	10 min.
Empty flying time ..	33%
Output per 5-hour day	900 feddans

It will thus be seen that the greatest time wasted is that in flying to the landing strip, refilling and returning to the field, *i.e.* empty flying time; in fact, 71% of the time in the spraying operation is taken up in this way. Spraying by this method produces an average daily output of 490 feddans, working a five-hour day.

Fig. 1. Aerial spraying contractors applying neat 'Fernadawa' at the rate of ⅛ gal. per feddan. Sudan, 1953

Unless an aircraft has a mishap, it has been found that, based on the above figures, 100% efficiency is obtained from the aircraft. As with land machines, much depends on factors such as the layout of fields and proximity of a suitable land strip, because, in favourable circumstances, outputs of 120 feddans per hour have been regularly obtained, and even 1,000 feddans in a six-hour day, but this is exceptional. This does show that in the absence of accidents the actual practical output efficiency of aircraft is much higher than with land machines, but this is to be expected to some degree in view of the very highly skilled personnel required for aircraft flying.

It is apparent from the foregoing figures that anything that can reasonably be done to reduce the 71% empty flying time will increase outputs considerably and reduce the cost of the operation. One way is to increase the size of the tank on the aircraft, but this then involves using a more powerful aircraft and the saving incurred is small in view of increased operational costs. The greatest saving can be obtained by reducing the volume to be applied per feddan. Experiments have shown that volumes below 1½ gal. per feddan can be efficiently applied; just how low it is possible to go is still uncertain, but there is some data available for applying ½ gal. per feddan efficiently on a semi-commercial scale. The data available is summarised in Table 1. (See also Fig. 1.)

It will be seen that by reducing from 2 gal. per feddan to ½ gal. per feddan there is an 84% increase in output from the same staff, thus producing a considerable saving in application costs.

When volumes of ½ gal. per feddan are applied by aircraft it is possible to apply a straight oil concentrate of DDT, so eliminating the expense of emulsifiers. This results in a considerable saving in the cost of the chemical and also eliminates the use of expensive water-carrying equipment. By this reduction in volume three savings are effected, namely: (1) increased output per machine and per man; (2) cheaper formulation of chemicals; (3) reduced ground equipment. Although this technique has not been put into full-scale operation, costings show a saving of approximately 2s. per feddan.

Further work is continuing with reducing the volume applied per feddan to even less than ½ gal. and ¼ gal. of spray per feddan has been applied successfully. Theoretically, it should be possible to reduce the rate of application even further, but some basic research on optimum droplet size is required before volumes can be reduced even further. That they can be

reduced is quite possible, but at present there are two schools of thought in respect to the preferable droplet spectrum required for such ultra-low-volume spraying. Theoretically, it would appear preferable for all the droplets to fall within a very limited range, thus allowing the maximum number of droplets from a given volume of liquid, also that these droplets should be as small as possible yet large enough to allow them to be deposited amongst the crop and to impinge on the leaf surface, so giving maximum cover of the leaf area of the crop. This would no doubt be a perfectly correct assumption if the application was carried out over a cold land mass with no air currents, but conditions in the Gezira are not of this order.

It is possible that a range of droplets within certain limits is preferable, so that an even amount of chemical is sprayed over the swathe width in spite of air currents. This is the method employed at present in aircraft spraying and has produced satisfactory results with an even dosage of DDT over the swathe. The larger droplets all fall within the swathe, but some of the smaller droplets are carried outside the swathe by air currents. There appears the danger that with an even droplet range a form of drift technique would have to be used when the volume per feddan becomes very low and the droplets are all below 70 μ.

The equipment used in aircraft spraying is fairly simple, the power for driving the pump being obtained from a small air-driven fan on the side or underside of the fuselage. Nozzles are of varying types, even low-pressure land-machine nozzles can be used satisfactorily. With ultra-low-volume nozzle equipment assuming greater importance, the size and droplet range must be known. This is particularly so when using pressure nozzles with aircraft, since there is no further break-up of the droplets in the slipstream as when a solid flow of liquid is released into the airflow of the slipstream.

Future experimental work

All the commercial spraying carried out so far has been done with the aircraft being used as an air-borne land machine over a controlled swathe width of 20 m. As outlined above, experimentation is still proceeding along these lines and has been so successful that some of the results have already been put into commercial practice. Experiments have also been carried out with drift spraying and are described by Joyce.[3] These experiments are continuing and providing a wealth of scientific data, but there are certain practical considerations which are worth while noting, as it is possible that the success or otherwise of this method depends upon them, not only in the Gezira, but elsewhere in the world where similar conditions exist.

The successful experiments carried out to date have been done on cotton numbers running east to west and the spraying has been done at the end of October under ideal conditions when the wind has been steadily blowing from the north. This is rather significant in view of climatic conditions in the Gezira during October. In the first half of the month the wind direction is practically constant from the south, but on approximately October 20 and for about a week it becomes very variable until it becomes constant from the north. A degree of its variability during this period is that during a single run by an aircraft the wind changed through 180° and then back 90°. Also during this period wind velocity fluctuates considerably. It therefore seems probable that during this period of wind change drift spraying would be a practical impossibility and that if it was adopted spraying would have to cease for a period of seven to 10 days.

Another consideration is that the cotton numbers in the Gezira run in all directions and are not constant. They can be sprayed by a drift technique, but the amount of chemical that would fall on fallows and other crops would be considerable. Again, with drift spraying, the chemical is not applied evenly over the swathe, although sufficiently evenly for jassid control. The problems arising from the insect complex in the Gezira have been discussed by Joyce and the advantages to be gained from the application of the minimum quantity of an insecticide to kill jassids without upsetting the biological balance of the other pests are given. Work is still continuing on this problem, but it would appear probable that the best results would be obtained by the application of this minimum quantity of insecticide on a controlled swathe, thus eliminating any danger of a 'semi-blanket' application due to drift on surrounding crops. It is also more than probable that the minimum quantity of insecticide required to achieve the desired results will be critical and any excess will disturb the biological balance in respect to other pests. The unevenness of drift application might quite well, therefore, be undesirable from insect complex considerations.

The drift of chemical on to surrounding crops also means that there is quite a considerable amount of chemicals being wasted. This loss of chemicals could quite easily offset any financial saving, which can be achieved by reduced application costs with this method of spraying, and could even turn this saving into a loss, particularly when comparing drift spraying with ultra-low-volume spraying.

In estimating the output from an aircraft on drift spraying in the Gezira it must first of all be realised that less than half the cotton numbers run east to west. If it is found that a 140-m. swathe is possible, then on these numbers only two runs with an aircraft are necessary, but on other numbers as many as eight runs would be necessary. It has been calculated that the maximum saving in the number of runs with an aircraft using drift spraying as opposed to the present method would be in the region of 400%, but the empty flying time would be the same, so that the actual saving would only be probably 300%. In addition, due to the wind, at least one week would be idle in the month of October, probably 10 days, so that the actual increase in output would only be in the region of 200%. This should give a considerable saving in application costs, but there are certain other factors which tend to offset this superficial saving, because with drift spraying there is the necessity for increased ground organisation, inter-radio communication between the ground and aircraft with scientific equipment for measuring wind direction and velocity, loss of load in the aircraft due to the radio installation and modifications to the engine because of the radio installation.

With land machines it has been proved that theoretical calculations can

Continued on page 324

General Irrigation Equipment

C. S. WRIGHT

Wright Rain Ltd.

The main types of overhead irrigation equipment, oscillating spray line, and large and small rotary rainers, are surveyed. A section is devoted to pumps and main lines, and the application of fertilisers and insecticides by means of the irrigation system is discussed.

MODERN irrigation equipment as it is known today was not developed until the beginning of this century. Until then the only mechanisation used in irrigation was the water-wheel, Archimedes wheel and other similar equipment, which were used to raise water so that it could flow by gravity to wherever it was needed.

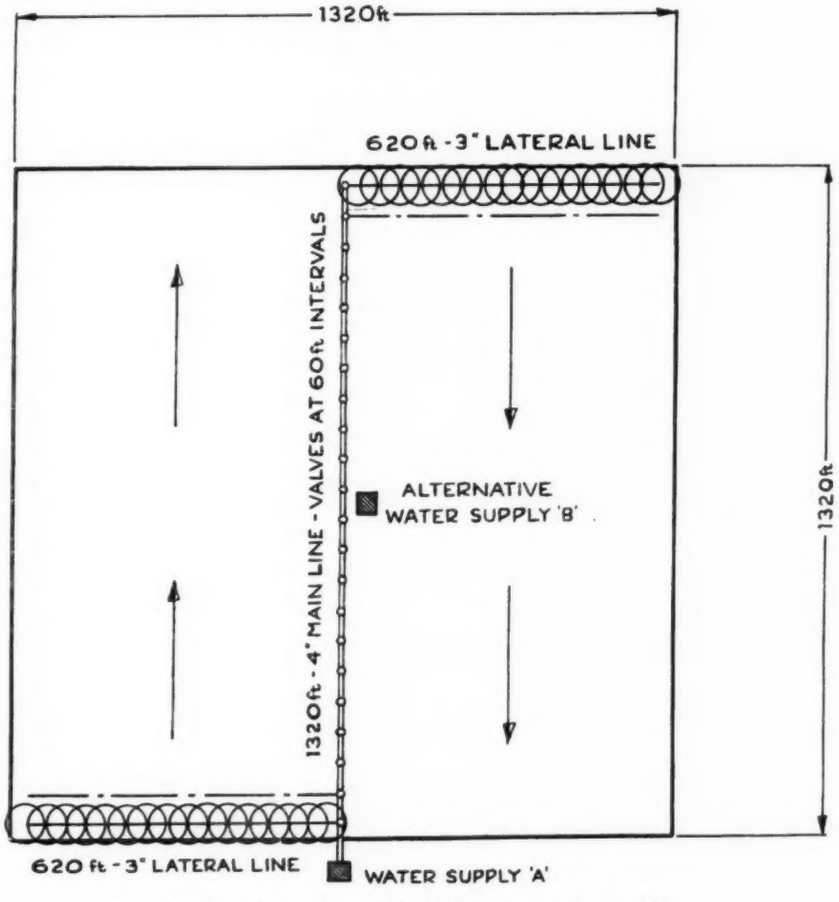
At the turn of the century, in New Jersey, U.S.A., an American started experimenting with steel tubing with holes bored at intervals along its length. This was probably the beginning of the authentic spray line, and the forerunner of overhead irrigation equipment. His idea was to use 2-in. steel pipe at the beginning of the line and gradually reduce the size, the whole being supported on permanent structures. The holes were drilled every 2 ft. or so, and it was arranged that this pipe should be oscillated by hand so that a strip approximately 25-50 ft. wide could be irrigated from one pipeline. This was a permanent installation, the steel line being installed at intervals of 50 ft. down the field. It was very expensive, but many growers installed this system and, in fact, some are still in use in the eastern part of the U.S.A. After the first world war the development in pipe joints made this system portable and it is now available as portable oscillating spray line.

In Europe at this time developments were taking place using large rainers for irrigation. These operated at a high pressure—80-100 lb. per sq. in.—and could make use of dirty water without blockage; they could also cover a large area from one position (as much as 2½ acres). Blockages were one of the earliest troubles of the oscillating spray line, as the holes were only $\frac{1}{64}$ in. in diameter. The large rainers have large nozzles, up to $1\frac{1}{4}$ in. in diameter, and are rotated by a small water turbine actuating through gears. At the same time, developments were taking place in California with sprinklers of a new and comparatively simple design. They operated at medium pressures, *i.e.* 30 lb. per sq. in., and were used with so-called lightweight steel pipe with lever-type joints and in conjunction with permanent mains.

The last war saw the development of lightweight aluminium-alloy tubing. This, together with better design of couplings and sprinklers, made this type of equipment most popular and it is now being used to irrigate hundreds of thousands of acres throughout the world. Gated aluminium pipe is also being used to take water where it is needed for furrow irrigation. Perforated aluminium pipe is used where uniformity of distribution is of no great importance.

Oscillating spray-line

Oscillating spray line, when used in short runs (as in the manufacturers' instructions), gives a very high degree of uniformity of distribution with a very small droplet size. This droplet


1320ft
620ft - 3" LATERAL LINE
1320ft - 4" MAIN LINE - VALVES AT 60ft INTERVALS
ALTERNATIVE WATER SUPPLY 'B'
1320ft
620 ft - 3" LATERAL LINE
WATER SUPPLY 'A'

A typical layout for sprinkler irrigation on a 40-acre field

size is very important, as a large droplet can have a detrimental effect on bare soil, causing panning and damage to young seedlings. The pipe is oscillated by an hydraulic motor driven by the pressure of the water. It needs comparatively clean water delivered at a pressure of 40-60 lb. per sq. in. The line has a maximum run of 400-500 ft., and is supported on stands throughout its length. Its manufacturers claim that two men can move 100 yd. of spray line to the next position in 15 minutes.

The spray line is available in lightweight aluminium tubing, and, by varying the nozzle sizes, the application rate can be varied from 1 in. in eight hours to 1 in. in six hours. Changing the nozzles, however, is a very long process, as there are approximately eight nozzles to every 16-ft. length of pipe.

Large rotary sprinklers or rainers

These large rotary sprinklers can cover up to 2½ acres from one position, depending upon the size of the nozzles. They operate from 80-120 lb. per sq. in., and have a radius of up to 190 ft. in still air. To obtain this radius the droplet size must be large. This does not make this type of sprinkler suitable for bare soil (due to panning) or very small seedlings (due to damage). As the jet of water is thrown high in the air, it is affected by wind, thus making it very difficult to get good, even distribution. This large rotary rainer is ideally suited for sugar-cane and bananas, where it is necessary to go over the top, the crop being too thick to go through or under. Its high operating pressure puts the power cost up, but, on the other hand, its wide spacing calls for slightly lower labour costs. It is very difficult to obtain the best possible degree of uniformity with this sprinkler. It should be spaced at intervals not exceeding 60% of the diameter of the circle wetted by the sprinkler, preferably on a triangular rather than a square pattern. It is also difficult to control the rate of application with these large sprinklers, although this is not important in such crops as those mentioned above.

Small rotary sprinklers

These are the most popular form of irrigation in the world today, especially when used in conjunction with lightweight aluminium-alloy couplings and tubing. They will operate from 15-60 lb. per sq. in., although some operate, not very efficiently, at a pressure of only 5 lb. per sq. in. These sprinklers can be split into three ranges according to the pressure used—15-30 lb. per sq. in., 25-45 lb. per sq. in. and 45-65 lb. per sq. in.—the middle range being the most popular. The 25-45-lb.-per-sq.-in. range combines a comparatively low operating pressure with a good wetted diameter, good distribution, and not too large a droplet size, especially when operated at its high-pressure scale.

The low-pressure range, 15-30 lb. per sq. in., is usually used for orchard work, when it is convenient to use a long but slow application, the sprinklers being moved every 12 hours in a 24-hour-day operation. Quite often a 12-hour set gives an application rate of 2-3 in. and is ideal for apples and citrus fruit, etc. A low-angle sprinkler is used for this purpose, so that the water spray stays below the foliage.

The medium-pressure range is the maid-of-all-work and is used for most crops. Its wetted diameter varies from 90-120 ft., and it should be spaced at not more than 60% of the wetted diameter. A common spacing for this type of sprinkler is 40 ft. × 60 ft., *i.e.* every 40 ft. along the sprinkler line with 60-ft. moves of the line. It can be used for all crops, high crops needing a tall standpipe. When used in conjunction with the new-type latch couplings, equipment sufficient to cover one acre can be moved to the next position by one man in 15 minutes.

The high-pressure sprinkler operating at 45-65 lb. per sq. in. is used only where intermittent irrigation is needed, and where the ground is protected by the crop. Its large wetted diameter needs a large droplet size, which can cause panning on a bare soil. With this type of sprinkler any length of line can be used, depending upon the diameter of the line and the size of the nozzle in the sprinkler. For example, 2-in. line up to 450 ft., 3-in. line up to 900 ft., and 4-in. line up to 1,500 ft., although for optimum working conditions these figures should be reduced by 20%.

A Sigmund Pumps Ltd. ' Rainer ' in action

Irrigation pumps

Water is usually supplied to an irrigation system by means of a centrifugal pump. Piston pumps can be used, but they should have relief valves etc. incorporated in the system, otherwise damage to the irrigation equipment will occur. The centrifugal pump is best suited for this work; it can be driven by an electric motor, petrol, petrol/paraffin, diesel or tractor power. For a static unit electricity is usually the best form of power, but in many cases this is not available. Where

Wright rain irrigating cabbage plants

a portable pump is needed consideration should be given to the use of a tractor as a source of power. It makes the pump unit completely mobile and also has the advantage of being backed by good service and spares. Another advantage is that the tractor will be useful all the year round, whereas very often with other forms of power the engine is only in use for part of the year. Of course, a tractor will be too powerful for a small scheme, *i.e.* 2-10 acres, but it is ideal for the 20-100-acre scheme. As a guide, 4 acres per h.p. is a reasonable figure, providing the water is close at hand, and when using medium-pressure sprinklers. Usually it is better not to irrigate more than 100 acres per pump unit. Power costs rise very steeply in the higher h.p. ranges and it will probably be cheaper in the long run to operate two pump units where larger areas are involved.

One of the problems associated with pumping irrigation water is the priming of the pump. If the suction lift is more than 12 ft. a foot-valve should be used. For suction lifts of less than 12 ft. a good hand-primer, preferably a rubber diaphragm type, is most suitable. Rubber suction hose can now be dispensed with, it being replaced with normal aluminium-alloy tubing used in conjunction with special foot-valves and suction joints.

Centrifugal pumps

There are numerous centrifugal pumps available today for irrigation purposes. It is preferable that they have a large-diameter impeller which enables the pump to be fairly slow running and still maintain sufficient head with no close clearance, or otherwise grit in the water will cause excessive wear. The pump should be easily accessible for maintenance, especially at the stuffing box.

Seals and valves

Mechanical seals may be used instead of packing, but are not recommended for these pumps. In addition, these pumps should be fitted with a pressure gauge and gate-valve. The gauge acts as an indicator for the correct performance of the pump and the valve is needed when priming with a hand-primer and also to control the flow of water.

Where the water is to be pumped up an incline it is advisable to incorporate a reflux valve or a non-return valve into the system to protect the pump and suction line. This valve should be placed adjacent to the pump. A valve is now available which incorporates a gate and reflux valve in one unit and this valve allows the flexible delivery hose needed for portable systems to be dispensed with.

Loss of pressure in the pump should automatically stop the power unit by the pressure switch. With internal-combustion engines heating or loss of oil pressure should also automatically switch off the unit.

It should be remembered that these units will be operating without attention over long periods and failure to take these simple precautions will result in a pumping unit being completely ruined.

Main lines

The water is taken from the pump to the spray line, sprinkler line or large rainer by either a permanent or portable main or combination of the two. When the pumping plant is in a fixed position and the land is intensively farmed, *e.g.* such as a market garden, permanent piping can be employed. For more general use, however, it is far more convenient and practicable to use a portable main line. A portable main line consists of lightweight aluminium tubing and couplings and can be easily installed by the user without the aid of trained engineers. Its portability allows land on either side of the pump to be irrigated with only one main line, the main line being moved from one section of the land to the next as required. (See layout diagram.)

With a portable pump there is no alternative but to use a portable main line.

As land usually slopes down to the water source, the main line is laid up a slope, and this allows the sprinkler line to run across the slope.

In a good design the sprinkler line should always be run across the slope and across the direction of the prevailing wind. In undulating country, where differences in height of more than 20 ft. are encountered, the sprinkler line should never be laid up and

down the slope. The up and down direction causes too great a pressure difference between sprinklers along the line, causing uneven application of water.

Fertilisers and insecticides

There are several types of equipment available for introducing fertiliser solution to irrigation water. These often consist of a container over the fertiliser and a Venturi tube or other device to make the water flow through the fertiliser.

However, the simplest method is that where a fertiliser solution can be introduced through the irrigation system at the pump. A solution is made and is then allowed to be drawn into the system through the suction side of the pump. It is usual to regulate the flow so that the spray lines, sprinklers or large rainers are able to oscillate or rotate at least five times whilst the fertiliser is being drawn into the system, thus ensuring a very even distribution of fertiliser.

Generally speaking, it is not practicable to apply insecticides or fungicides with irrigation water owing to the very great dilution which occurs.

Conclusion

There are, then, three main types of irrigation equipment in use today—oscillating spray line, large rotary rainers, and small rotary sprinklers. The spray line, with its high degree of uniformity of distribution and small droplet size, is very suitable for use on young seedlings, but its relatively short maximum run and the need for very clean water makes it less suitable for general use.

The large rotary rainer has the advantage of being suitable for use with very dirty water and, by covering a large area at one setting, is economical in labour costs. The large droplet and somewhat uneven distribution, however, make it suitable for certain crops only, and the high power costs more than offset the saving in labour.

The small rotary sprinkler is, perhaps, the happy medium between the oscillating spray line and the large rainer. Very dirty water must be screened by line filters to reduce the possibility of blockages, but the comparatively low operating pressure, good distribution and general portability make it ideal for the majority of world crops.

New Nevada Dam

Construction of one of the highest earthfill dams ever to be built in Nevada, on the Alder Creek Ranch in Humboldt County, 20 miles south of Denio, was recently completed by Willis Brothers, Paradise Valley, Nevada.

Purpose of the dam is to establish a reservoir which will provide additional irrigation water for Alder Creek Ranch's large alfalfa crops and to make it possible to put additional acreage, now barren, into production.

Dimensions and capacity

The dam embankment on the Willis Brothers' venture is 252 ft. wide at the base, 50 ft. high and 340 ft. long. The structure is earthfill, decomposed granite and a mixture of granite and clay with air-placed concrete seal on bedrock; it is 100% compacted in a 30-ft. wide centre strip above the seal. Elevation at the dam site is 7,200 ft. and the reservoir will store 1,628 ft. of water at a depth of 40 ft.

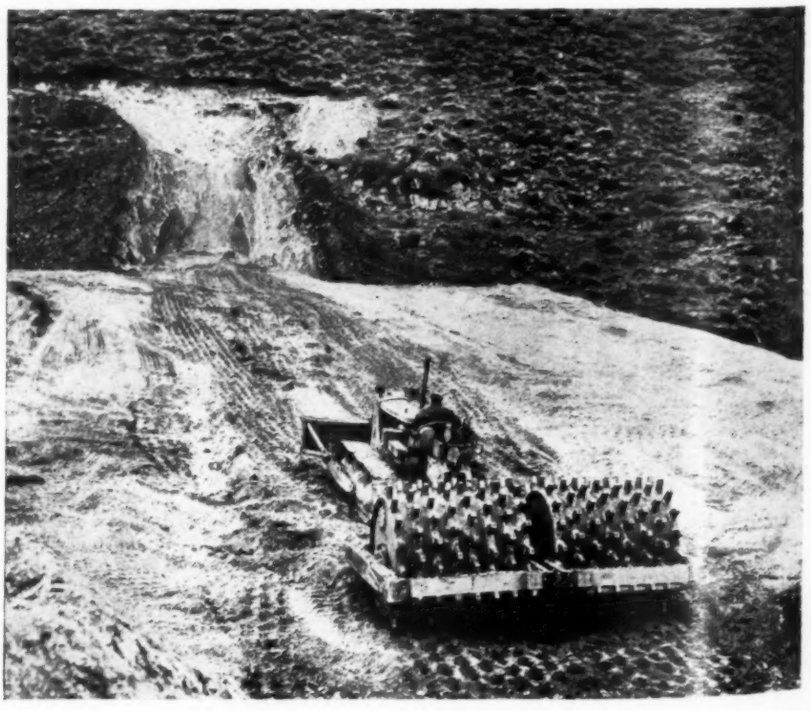
A newly-built dirt access road twists and winds for approximately eight miles to reach the reservoir from ranch headquarters. This switchback mountain road fords a creek several times and was built with the assistance of two Caterpillar track-type tractors pulling scrapers and two 'dozer-equipped crawlers and a sheepsfoot tamper. These same machines also constructed the dam.

Work on the earthfill structure began in mid-July 1954 and the first snowfall of the season, just three months later, found the contractor hurrying to finish the project, which involved an overall total of 44,000 cu. yd. of excavation.

Conditions for filling

Alder Creek Ranch has its wells and the spring-fed Alder Creek as water-supply sources, but the reservoir will boost the water supply substantially in the interests of more alfalfa crop.

The creek runs 2½ cu. ft. per sec. in the summer and will not, by itself, fill up the dam's reservoir. The ranchers, however, are counting on winter snowfall to help build up the water supply. The winter of 1953-54, for instance, although considered open, brought 2 ft. of snow to the region.



A Caterpillar D6 tractor pulls a sheepsfoot tamper to compact a layer of earth on the big earthfill dam being constructed on the Alder Creek Ranch in Humboldt County, Nevada

Russian Comfrey—Food for Thought

L. D. HILLS

Increasing interest is being shown in the once-neglected perennial Russian Comfrey. Reputed to yield up to 100 tons of foliage per acre under favourable soil and climatic conditions this plant is receiving more attention by farmers and researchers. Although the cost of stocking is high, this is offset by the long bearing life of the plant; it may grow for up to 20 years on the same site without showing signs of deterioration.

IN 1952, when the writer sent his first plants of Russian comfrey (*Symphytum peregrinum* Ledeb., Order Boraginaceae) to Southern Rhodesia, it was with the warning that this natural hybrid of the prickly comfrey (*S. asperum* Lebech., formerly *S. asperrium* Donn.) and the common comfrey of the herbalist (*S. officinale* Linn.), introduced from Russia about 1870, was unlikely to be of value in tropical or subtropical climates. The results from this first import (and others in increasing quantity as the plant proved itself to the satisfaction of those who grew it) were entirely unexpected.

Yield trials

In 1954 the Henry Doubleday Research Association began a programme of farm-scale yield trials and experiments designed to replace opinion on this crop with observed results in Britain and overseas. These trials by voluntary effort, financed extremely modestly by private donations, cannot be compared with those carried out from time to time with one species of comfrey or another by research stations. The majority of the plots are very much larger than those hitherto planted by research stations in any country; all are using the same methods of cultivation, which are those used in the 1880s and 1890s, to secure yields up to 100 tons/acre (see *J. R. agric. Soc.*, **18,** 1882), and all are using known strains of *S. peregrinum*. The 13 plots in the British Isles in 1954 and the 18 in 1955 are spread over a wide area. The 1955 British plots range from Scotland to the Channel Islands and they include a sufficient variety of soils and climates to even out any exceptionally favourable or unfavourable conditions; the minimum duration of three years should rule out the effect of exceptional seasons such as 1954.

It is the overseas plots that provide the most serious food for thought for all concerned with agricultural research, for evidence is accumulating on the farms which now justifies a re-examination of the possibilities of this crop in the light of recent discoveries.

From the experience of farmers in Kenya, it appears that in climates where frosts are unknown or temperatures do not fall below 28°F. at the coldest part of the year Russian comfrey is in production all the year round. In Britain it is normally dormant from the end of November to the beginning of April. This protracted cutting season not only increases the yield, but the availability of green fodder at dry periods adds an agricultural value unknown in Britain. If the offsets (seed is rarely set and is genetically undesirable) are planted in a tropical country during the rainy season when temperatures are high, irrespective of the month in the year that this may be in relation to British seasons, they grow with great vigour. The root development appears more rapid and, though these roots have been measured penetrating up to 12 ft. in England, how far those of an established plant will go down in Africa is as yet unknown.

The following example is from Mr. E. McInnes, of Innesfree Farm, Nakuru, Kenya. The plot was planted in July 1954, the offsets 3 ft. apart and 3 ft. between rows, accurately spaced to allow clean cultivation by row-crop machinery. (Yields are shown in Table 1.) The altitude is 7,000 ft., facing west, and the crop is fed to dairy cattle. The plot is open for inspection by interested parties and Mr. McInnes will be glad to give the fullest information on his growing methods. Success in Kenya is not necessarily relevant to the west coast, though it is hoped that new plantings on the Gold Coast and in Nigeria will provide information during 1955 and 1956.

A British plot of this age is claimed by those who sell offsets to produce between 20 and 30 tons an acre; 36 tons is a record. Mr. McInnes intends to continue cutting and weighing whenever the crop is knee deep but during the cutting period only 13 in. of rain have fallen. If the delayed long rains come the last four cuts may be larger.

TABLE 1
YIELD PER ACRE FROM INNESFREE FARM, KENYA (UNIRRIGATED)

	Tons	*Cwt.*	*Lb.*
1st cut, November 1954	5	18	64
2nd ,, December ..	6	9	72
3rd ,, January 1955..	8	12	97
4th ,, February ..	6	9	72
5th ,, March ..	7	11	28
6th ,, April	12	6	37
7th ,, May	15	2	60
8th ,, June	10	5	31
Total	73	16	13

The rate of growth appears to have been increased by higher temperatures, and another Kenya grower, Lady Betty Markham, considers that 4-ft. or even 5-ft. spacing in rows and between rows would be desirable in Africa because the plants grow as large circles of growing points and these tend to meet in the rows so that mechanised cutting is difficult without damaging the crowns. In England, where it is not until the fourth season that the crop yields full production, closer spacings are usually suggested by those who have never seen established plots.

Analytical results

The analysis figures from Africa show that the composition of the

Part of an acre of Russian comfrey near Exeter. It is fed to pigs on a pasture alongside The main consideration in siting a plot is a short carry for the heavy crop; this cut was over 10 tons, the next over 14

foliage differs little from that given in *Min. Agric. Bull.*, No. 48, 'Rations for Livestock', p. 128, *i.e.* crude protein 3.4%, fibre 1.5%, carbohydrate 4.9%, oil 0.38%, ash 2.3%, moisture 87.6%. As, however, there is evidence from the British plots that Russian comfrey analyses vary in the same way as that of grass, with a spring and early summer protein peak, a set of values for the 12 cutting months would be desirable. Because of the distances involved it is unlikely that this can be carried out other than by a research station, and it should be recognised that it is important to cut each sample at the same stage of growth. As with lucerne, the protein falls and the carbohydrate, fibre and ash increase as the crop runs to flower and stem.

The British fresh-weight analysis is of value as a guide to feeding. The foliage is fed chaffed till the beasts are accustomed to it, and then is used as part of the production ration; it is too low in starch equivalent to be a complete diet and needs to be balanced with a carbohydrate-rich feed, even one high in digestible fibre only. The dry season production is of great value; the bulk produced in the rains is available for conservation. More work on this is desirable. It was the failure of George Fry's 'sweet ensilage' process and the difficulty of hay-making owing to the thick stems and mid-ribs that caused the crop to fall from favour in Britain during the agricultural depression of the 1890s.

Silage-making

In Kenya silage is made with green maize and molasses to balance the problem of the very close ratio of protein to carbohydrate in Russian comfrey, and Mr. McInnes is experimenting to find the most suitable proportion. In Scotland, Mr. J. W. Hobbs, of Fort William, has for many years added 25% of comfrey from this three-acre plot to the cereal-legume mixture he normally uses, in order to increase the protein value from 10% to 14%. The Kenya lucerne-hay barn, a series of sloped bamboo racks under a corrugated-iron roof, appears to offer a solution for hay-making. A modification of this, developed from the experiences of British growers, is now under trial, using sun heat and requiring only materials available locally. Although Russian comfrey can be dried in a normal grass drier, provided it is put through a shredder first to remove the difficulty of the leaf over-drying while the stems are still wet, the heavy capital investment and high fuel cost of these machines makes them unsuitable for use in undeveloped countries. Table 2 shows the type of material produced.

Growth characteristics of comfrey

In Southern Rhodesia the growth cycle of the plant is rather different because there is a definite dormant period during the cold, dry weather at the present growth stage of the plots in the Federation. This may be reduced with greater root depth, but the night frosts at the altitudes where the crop has been grown so far are sufficient to stop the growth even under irriga-

TABLE 2

ANALYSES OF BRITISH RACK-DRIED RUSSIAN COMFREY AND AFRICAN SHED-DRIED RUSSIAN COMFREY, WITH COMPARATIVE FIGURES FOR COTTON CAKE, GRASS MEAL AND LUCERNE-LEAF MEAL

	Protein, %	*Fibre*, %	*Carbohydrate*, %	*Oil*, %	*Ash*, %	*Moisture*, %
Rack-dried British Russian comfrey:						
May 13, 1954 ..	28.86	9.75	26.45	1.63	10.11	17.20
May 22, 1954 ..	33.68	9.36	32.23	2.17	14.89	7.73
June 22, 1954 ..	26.59	10.59	32.21	1.57	17.60	11.44
July 26, 1954 ..	23.03	12.07	31.41	1.23	15.56	16.70
August 11, 1954 ..	23.38	13.00	29.63	0.99	16.17	16.83
September 28, 1954 ..	23.58	12.00	35.64	1.34	16.55	10.89
October 22, 1954 ..	18.80	10.64	38.06	1.33	18.40	12.77
Shed-dried African (Southern Rhodesia) Russian comfrey:						
May 24, 1954 ..	20.44	9.69	36.70	1.77	18.75	12.66
August 30, 1954 ..	21.40	10.90	35.20	3.40	21.40	10.40
Egyptian cotton cake ..	23.20	21.30	32.60	5.00	5.80	12.10
Average grass meal ..	20.00	14.00	41.90	5.80	8.00	10.00
Lucerne-leaf meal (American)	21.40	24.50	40.60	1.90	10.20	9.00

tion. Table 3 shows the yield obtained by Mrs. M. Ridsdale, Derna Farm, Salisbury, Southern Rhodesia, who feeds the crop as green fodder to poultry. (The wide ratio of protein to fibre makes pigs and poultry the most profitable stock for utilising the crop. It has been used as a vegetable for human consumption in the past and experiments in Ceylon and South Africa are being carried out to determine its nutritional value as a direct source of vegetable protein.)

TABLE 3
YIELD PER ACRE FROM DERNA FARM,* SOUTHERN RHODESIA

	Tons	*Cwt.*	*Lb.*
1st cut, April 1954 ..	13	6	57
2nd ,, May	4	11	84
3rd ,, June	1	3	39
4th ,, October ..	1	5	4
5th ,, November ..	4	7	98
6th ,, December ..	4	4	100
7th ,, January 1955..	13	13	74
8th ,, February ..	11	9	77
9th ,, March ..	9	5	1
Total	63	7	86

*This plot was planted in September 1953 and is grown without irrigation.

In this case the cuts are of definite trial plants, for those who feed green on a daily ration never mow the whole area at once, and, although growth may be at a standstill during July, August and early September, it is still possible to cut, in the same way as marrow-stem kale would be in England using the stored production in the plants. It is possible that fully established plants would have allowed the number of cuts to be increased during the rainless period, which ended before the January cut. A second plot in the same area, but planted two months later, produced 49 tons per acre.

In South Africa the dormant period appears to vary between three and four months, but there is such a wide difference in climate between areas that the yields for two months reported by E. Brandmuller (Vereeniging, the Transvaal) in an article in *Farming in South Africa* (November 1926), with what appears to have been pure *S. Asperum*, are also likely. The one plot in the trial at Gordons Bay recovered from the dormant period well and yielded 7 tons 8 cwt. by the end of November. Further cuts were impossible because of high winds. These

Part of half an acre of Russian comfrey near Colchester; its yield, cut and weighed by the local Agricultural Officer, was over 28 tons. As it is only in its second season, it may well reach 100 tons an acre by 1956, particularly if the next growing season is more clement

are a new hazard for the crop because a full-grown Russian comfrey plant has a very considerable sail area and is not designed to bend in the wind like a grass, for in both Russia and Britain it is dormant at the time when high winds can be expected. No other plot overseas has had this trouble and experiments with windbreaks may bring it into production again. Hot winds wither the growing points, but winds of normal velocity do not appear to be harmful.

New Zealand results

At Waimate, in the South Island of New Zealand, a second-year plot has achieved 62 tons per acre in six

Pigs of all ages eat Russian comfrey greedily. Fed while they are still on the sow, it removes both the risk of scour and the problem of the small pig in the large litter. The cheap vegetable protein with very low fibre content is a valuable supplement to more evenly shared sows' milk

cuts; the first, of 7 tons, was cut after a spring drought. The production in a dry year on poor land compares very well with the 40 to 60 tons claimed by British nurserymen selling comfrey for plots of this age.

In Britain, with a cold spring and a wet, cold summer, the three established plots produced 58, 53 and 44 tons an acre; the best second-year planting was 34 tons and the average for nine plots, of this age only, was 25 tons, over double the best yield of the Hannah Dairy Research Institute in 1944 (see Holmes, W., *Agriculture*, February 1946). As the trial continues and the proportion of established plots increases it may be possible to calculate an average yield for those of four years and more. (The productive life of the crop is 20 years and its position in the farm rotation should be that of an orchard; the site should be one convenient for both feeding and dunging as a permanent crop.) Whether this average will include any producing the often-quoted figure of 100 tons an acre will depend on the fertility of the land, the weather and the skill of the farmers concerned, as with the yield of any other crop.

Conservation

The produce was mainly fed to pigs on the Lehmann system, thus producing a considerable meal saving; from two plots it is used largely for calf rearing, as a scour preventive and a source of cheap protein, a purpose that it also serves even more successfully for pig breeders; and on another as a conditioner and scour preventer for mares and foals and a saver of high-quality hay for stallions and hunters. Until conservation can be mastered it is unlikely to be of great value to the British dairy farmer.

The bulk production is at a time when grass is the cheapest feed and, although in dry summers it is a valuable standby, it offers far more to the pig or poultry farmer (and the riding school) in Britain at the time of writing. A heavy tonnage in March and April in Kenya is, however, a phenomenon that brought over 100 visitors to the plot where this was recorded, not concerned with the total yield, but simply to see a fodder crop that was *green*, not withered and dry at this season.

During 1954 over 50 samples of dried Russian comfrey from the trial were analysed by Horace Ward, of Grange-over-Sands, and Unilever Ltd. The drying methods used were those practicable only on a small scale, but from the experience gained it is hoped to develop a simple, cheaply constructed drier for Britain and overseas. The product is, in the opinion of Unilever Ltd., more attractive to compounders than dried grass, because of its lower cost, higher average protein and low fibre (see Table 2), which makes it more suitable for pig meal. Production per acre with a 50-ton crop on a 10% moisture basis as meal would be approximately 8 tons, compared with that of 5 tons of grass meal per acre secured by the winner of the R.A.S.E. trial in 1953.

Disadvantages

The chief disadvantage of Russian comfrey as a crop is the first cost of the offsets, £15 to £20 per 1,000, and, although this is written off during its long life, the 4,840 (approx.) plants required per acre are a large capital investment. The plant is a semi-sterile hybrid with a malformed flower structure. It occasionally sets seed with its own pollen; *S. officinale* is more common in this respect. Seedlings, which take three to four years to reach planting size, either segregate out to reproduce the less productive variations of both parents or the less desirable results of a back-cross to the lower yielding of these ancestors. It is from the results of seed raising in the past and later back-crosses that the mongrels of many British hedges descend, and many of the unfavourable opinions of comfrey overseas (see the Kew Annual Report for 1879) arose as a result of exporting seed. Today it is an easy matter to export perishables in ships' cold chambers or as air freight.

Local propagation in Africa is now reducing planting costs. The usual procedure is to plant only a small area and if this proves successful under local conditions to increase by division, and by planting inch-long sections of root along a trench, like beans. These are then replanted sufficiently at a later stage. It is because of this custom that established plots on the British scale are rare.

No one in Africa or New Zealand has yet discovered the old disadvantage that ' you can't get rid of it '. The answer is folding pigs or poultry on the area to be cleared; one plot has already been destroyed in this way by accident. In England a tethered pig is the best method of clearing a hedgerow and the simplest solution for pasture clearance is sowing to a clover and chicory ley in combination with pig grazing.

Conclusion

To sum up, the evidence now available is that the plant is a very rapid converter of nitrogen into protein and that, on a bulk-for-bulk basis, the low production of fibre compares favourably with the grasses. It is not a legume and therefore the required nitrogen must be supplied either as a heavy dressing of dung given to all the farm plots or as a fertiliser. The crop has the disadvantage that it must be vegetatively propagated and the planting cost per acre is high. Such disadvantages are balanced by the high yields that can be obtained, particularly in warm, temperate climates, coupled with the ability to produce green fodder during dry periods.

The place of this crop in world agriculture depends on extending trials and research to further regions and further sets of conditions. Where the initial trials indicate that the crop is well adapted to local conditions, then research and development work should be directed to the discovery of the optimum fertiliser dressings, the selection from the variations of existing strains of any pure clones that may be of greater productivity or nutritional value and methods of conservation and feeding suited to local conditions. These are programmes for the future; in the meantime the results so far provide food for thought.

To Authors and Readers

The publishers of WORLD CROPS invite the submission of manuscripts of books to be considered for publication. All manuscripts will be promptly acknowledged and carefully considered by qualified experts. A synopsis with chapter headings should be sent in the first instance, addressed to the Book Production Manager.

The publishers are specialists in industrial, technical and scientific books and have a world-wide selling and distributing organisation.

The Use of Sprinkler Irrigation Systems in Central and South America

DEBORAH GILBERT

Irrigation Development Corporation, New York

Enormously increased yields have been obtained in Central and South America with the use of sprinkler irrigation systems. Corn and wheat yields have been doubled, rice production has been increased by nearly 80% and orange groves are now growing in what was previously unproductive desert. Sprinkler-type irrigation permits the growth of cover crops to control erosion in orchards located on mountainsides.

PORTABLE aluminium sprinkler irrigation systems are a relatively recent development, but they have already demonstrated their outstanding value in all phases of agriculture in all parts of the world. Man-made rain has long been regarded as an ideal way of providing moisture to crops exactly when and where it is needed; but for nearly as long it was almost always an unobtainable ideal because of its great cost. Now aluminium has made sprinkler irrigation compact, portable and economical. Sprinkler irrigation offers many advantages over surface, or flood, irrigation. It is widely considered as the most efficient way of irrigating.

Available for all soil types

Sprinkler irrigation can be used effectively on any type of soil and it provides uniform distribution of water over the entire field. With sprinklers it is not necessary to level and grade the land, as must be done with flood irrigation. Field ditches and furrows are eliminated, thereby making more land available for cultivation. In comparison with other methods of irrigation water savings as much as 60% are possible. Hillside irrigation is feasible and it is possible to grow cover crops to control erosion in orchards located on mountainsides.

With sprinkler irrigation the alkali problems that accompany surface irrigation in many areas are eliminated. There is no leaching of soil nutrients and no waterlogging. Marginal land along the banks of rivers and streams, which is not suitable for any other form of irrigation, can be sprinkled successfully. Sprinkling eliminates the weed problem along irrigation ditches, and water-soluble fertilisers, as well as insecticides, can be distributed through a sprinkler system.

Basic components

What are the basic components of one of these sprinkler irrigation systems? First, of course, there must be a water source—a well, a river or other stream, or a pond or reservoir. The system itself consists of a pump, aluminium tubing, aluminium fittings and sprinklers. The pump may be powered by an electric motor or by a gasolene or diesel engine. Where electricity is not available in sufficient quantity or cheaply enough, irrigation engineers favour the diesel-powered unit as the most durable and economical in the long run. However, pumps designed specifically for irrigation work, such as those of the Irrigation Development Corpn., are made with both gasolene and diesel power units to meet all needs. The pump size will, of course, depend on the size of the system as a whole and the amount of water that is to be distributed.

Aluminium irrigation tubing is manufactured in diameters varying from 2 to 8 in. and in standard lengths up to 40 ft. It is rustproof, offers excellent corrosion resistance, can withstand working pressures up to 450 lb./sq. in. and is easily portable. (A 30-ft. length of 3-in. tubing, for instance, weighs less than 17 lb.; a 30-ft. length of 6-in. tubing weighs less than 40 lb.) This type of tubing is used for the main line, which is connected directly to the water source, and for the sprinkler, or lateral, line as well. The main line has specially designed T-valves spaced at equal distances along its length. These valves are activated by a valve-opening elbow at one end of the sprinkler line. The sprinkler line, which is usually placed at right angles to the main line, has sprinklers located at regular intervals along its length and is moved from position to position until the entire area has been covered.

The fittings serve several functions besides that of linking together the separate lengths of pipe and are actually the components that give the system its flexibility. There are many types of fittings, including simple couplers for main-line and sprinkler-line tubing, couplers that carry sprinklers, end plugs, T-valves for main lines and valve-opening elbows for sprinkler lines.

Sprinklers are manufactured in a wide variety of types and sizes. They range from small-capacity sprinklers that cover an area about 25 ft. in diameter to giant sprinklers that distribute over 600 gal. of water per minute and cover an area more than 400 ft. in diameter.

Results in South America

How have these systems worked in South America? A good answer can be obtained by referring to some examples cited:

Coffee trees that used to produce less than 40 arrobas (approx. 1,000 lb.) per thousand now produce 80 arrobas per thousand. On a nearby fazenda figures have risen from less than 25 to over 70.

Orange trees are blooming on land that a short while ago was unproductive desert.

Corn yields are doubled—from 60 to 152 bushels per acre—and wheat yields are nearly quadrupled—from 7 to 27 bushels per acre.

Over 125 sacks of rice are being

harvested from land where only 70 grew before.

Pasture-lands now support twice as many cattle as they once did and support them better. In some places as many as four head of cattle are grazed on a single acre.

Instead of the usual one bale per acre, four bales of cotton per acre are harvested for a profit of over $400 per acre.

Soya-bean yields are nearly double, beans are 50% larger and contain 11% more oil.

Three farm workers are now doing the work of 52, but they have not deprived the other 49 of their jobs.

The great increases in coffee production were both obtained in the State of São Paulo, Brazil. An owner installed one of the first sprinkler systems in the State. This is a 'Wade-Rain' system, which draws its water from a 35-million-litre reservoir. The system itself consists of easily portable lengths of aluminium tubing (a total of 2,600 lineal metres in all), which are connected by self-draining couplers. The couplers, which are also self-locking and so designed that they cannot become unlatched during operation, carry the risers to which the sprinklers themselves are attached. In this case a riser is attached every 30 m., with each riser carrying twin sprinklers—one that distributes water in a radius of 15 m. and the other in a radius of 15-30 m. The pump is operated by a 70-h.p. motor; it is capable of driving water at proper pressure for sprinkling for a distance of 2 km. When operated 21 hours per day, this system can, in two weeks, irrigate 100,000 trees with the equivalent of 30 mm. of rain.

Before the system was introduced it was calculated that it would be necessary to increase production 20% (*i.e.* from 38 arrobas per thousand trees to 45 arrobas per thousand trees) in order to liquidate the cost of installation and operation within a two-year period. As a matter of fact, this expectation proved far too conservative. After the first year of operation it was reported that output had more than doubled, for the trees yielded 80 arrobas per thousand, enough to pay for the system and to provide increased profits as well.

This owner, who is a member of the Sociedade Rural Brasileira, expressed the reasons for his preference for sprinkler-type irrigation by saying that sprinkler irrigation saves water, avoiding the losses common in other types of irrigation. By distributing water evenly over both high and low spots, sprinkling discourages erosion and prevents the accumulation of water in low spots. Furthermore, sprinkling creates an atmosphere of humidity which makes cultivation easy, and the gently falling water, like natural rainfall, washes the trees and opens the pores of the leaves. Other growers have reported that sprinkler irrigation, in addition to all these advantages, is much more economical than surface irrigation, for it eliminates the need for cleaning ditches and repairing gates; it saves the expense of levelling land; it permits the use of all the land for planting and it saves on labour costs.

Irrigation pump designed by Irrigation Development Corpn. A portable, packaged DMD-type pump mounted on a heavy-duty four-wheeled trailer. Maximum capacity, 1,600 gal./min.; maximum pressure, 250 lb./sq. in.

Another coffee grower who owns a ranch in São Paulo claimed that, by the installation of aluminium sprinkler irrigation, his 110-alqueire estate could produce more than the 400 alqueires of his neighbour (1 alqueire equals five-sixths of an acre). He was proved correct, for he harvested 1,225 sacks of coffee from his trees, whereas those of his neighbour yielded only 600 sacks.

This was an exceptional harvest. For many years the drought problem had been growing worse. Coffee production had been declining steadily and dropped below 25 arrobas per thousand. Then, in 1952, the sprinkler irrigation system was installed on his estate. Here is how he describes the results:

'Ten days after the machinery was put into operation the land began to flourish. There had been a period of intense drought and prospects for the harvest were as bad as could be. The first irrigation was carried out over a period of 20 days and a second one was carried out soon thereafter. Within a very short time the flowers and new leaves came out. The dry coffee trees turned green and lively. Production soared. Plants that used to produce 25 arrobas per thousand produced 50. In the next harvest every 1,000 gave 70 arrobas and, in addition, the newer trees, only four years old, bore fruit. I trust that the next coffee crop will match the previous one'.

The system for the coffee trees paid for itself the first year and this success encouraged the irrigation of other crops. Excellent results have been achieved with his rice plantation, where production has increased from 70 to 130 sacks per alqueire.

Outstanding results in irrigating rice are also reported in Porto Ferreira, Brazil. The ranch in question is located at a high altitude where a February harvest is almost unheard of, but the owner harvested a bumper

crop of rice—700 sacks from only 6 alqueires. He accredits both the size and the early maturity of his crop to irrigation, and he is greatly pleased because the early harvest permitted him to double-crop his land. Potatoes and grain were planted at the end of the rice harvest with complete success.

The three farm workers who are doing the work of 52 are employed by a farmer who has 40 alqueires of land planted mainly in lettuce near the city of São Paulo. His 'Wade-Rain' system consists of a 20-h.p. electric motor, a pump with a capacity of 1,200 litres per minute, portable aluminium tubing and 20 sprinklers. Before he installed his system he needed 52 workmen to irrigate 4 alqueires of lettuce in a day by conventional surface irrigation. Now, with each sprinkler covering an area of 700 sq. m. in a few minutes, the equipment does the same work more thoroughly and uniformly in four hours, and only three men are needed to operate it. However, this increased efficiency has not resulted in any so-called technological unemployment, because the production of the farm has increased so greatly that the other workers have been absorbed into additional activities. As an investment, this sytem has paid off rapidly and handsomely—within a few months the cost of installation was recovered in increased profits.

Requirements

Successful sprinkler irrigation naturally is not a matter of setting up tubing and sprinkler and applying water haphazardly. But neither is it unduly complicated, and the farmer himself need not be a technician in order to irrigate his land properly. Given the necessary information, a trained irrigation engineer can design the proper system. The engineer needs to know the following:

(*a*) The amount of water available and where it is located with reference to the land to be irrigated.

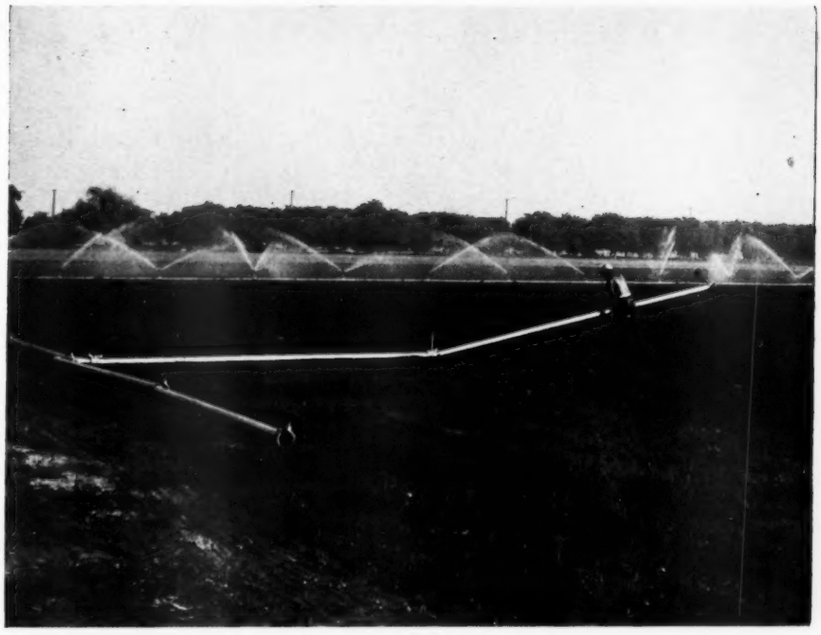
(*b*) The type of soil present and how deep it is.

(*c*) The crops that are to be grown.

(*d*) The relative elevation or the varying elevations of the land with particular reference to the water source.

(*e*) The direction and strength of the prevailing wind.

(*f*) The amount of water that must be applied and how often.



This lightweight-type sprinkler irrigation system incorporates a patented, self-locking coupler that cannot be unlocked while the sprinkler is in use. The units are light and easy to move. 'Wade-Rain' systems lock from the carrying position

Efficient questionnaires (obtainable from Irrigation Development Corpn.) have been designed to elicit all this information and aid the farmer in presenting all the data needed to design a system to meet his particular needs.

Once installed, a portable sprinkler irrigation system is simple and efficient to operate, requiring a minimum of upkeep and labour. In practice, the problem of how much water to apply is not too difficult. Although crop needs vary, a good general rule to follow is to irrigate sufficiently to keep the soil at one-half of its water-holding capacity. A new device now makes it possible to determine easily and accurately when this point is reached. The device is known as the 'Irrigage'. It is an electric moisture meter, battery-operated, which measures the water content of the soil at 6, 12, 18 and 24 in. A plaster of Paris stake is inserted in holes in the soil previously drilled with a tapered auger. Sensitive cells located in the stake quickly transmit moisture readings to the meter. The device permits the farmer to plan his irrigation needs well in advance, to avoid unnecessary sprinkling, and to shut off the water as soon as the soil reaches the desired degree of moisture. In cases where it is desirable to maintain the soil at either more or less than 50% of its water-holding capacity, the 'Irrigage', of course, furnishes the necessary information also.

Portable sprinkler irrigation, it is true, takes careful thought and planning, but it has demonstrated its value and has shown that it is well worth not only the thought and planning, but the investment as well. Sprinkler irrigation systems are now in use all over the world for such diverse crops as pastures, tobacco, cotton, sugar-cane, sugar-beet, grapes, oranges, cocoa, bananas, apples, corn and grain, to mention only a few. Everywhere its users are enthusiastic about it and they all report that sprinkler irrigation systems give them better control of irrigation water, save them money on labour costs and perhaps most important, from the individual point of view, provide substantial increases in crop yield and profits.

Myxomatosis in Hares

It has now been confirmed that a British brown hare (sp. *Lepus Europaeus occidentalis*) killed by a dog at Wilton, Wiltshire, recently, was suffering from myxomatosis. This confirms the findings in France that in rare instances the hare may be affected, but it is emphasised that there is no evidence that the disease affects other animals or human beings.

Yugoslav Agriculture's Ten-Year Plan

M. GORDON

Although 10 years have passed since the end of the second world war, Yugoslavia still finds herself in the invidious position of being a country with potential agricultural reserves and yet having to import cereals, fats and other agricultural products. However, a £2,000 million land-reform programme has been instituted which will be spread over a period of 10 years. By this means it is hoped that with increased and superior production her economy will be stabilised and that many benefits will accrue to her farming population. Mr. Gordon outlines the official view.

NO country in the world faces a larger and more complex agricultural problem than does Yugoslavia. Although it has some things in its favour, it has a vast range of problems, for it has an unhappy past in this sphere, and the human element in the shape of ignorance and prejudice is just as much an obstacle to progress as is the lack of technologists and machinery.

In fact, a review of the position would almost lead to despair, for it seems that whatever can be wrong or lacking is evident in the Yugoslav agriculture. An agricultural country, with an area slightly in excess of that of Great Britain, the pre-war position was incredible. The whole of this vital industry languished for lack of capital, lack of knowledge, by an excessive agrarian population and by a primitive technique, which produced the minimum with the maximum labour and lost much of even that produce because of waste due to inferior means of packing, transport and storage.

The precarious position of the population was made even more uncertain by an absence of irrigation which left large regions open to drought. Nature indeed was the master, able to inflict bankruptcy by floods or dry spells, and by visiting crops with pests and diseases which man has long known how to control. In every sphere production was derisory, and many of the crops were of an inferior type even at their best. What Canada could produce with the labour of 4.5 land workers, America with 7 and England with 12, Yugoslavia could only produce with 44 workers.

Harvesting in Srem district, Vojvodina

State of holdings

The average agricultural holdings in Yugoslavia amounted to 13 acres, as against 37 in France, 74 in England and 197.6 in America. That production is bound to be severely limited on such fragmentary holdings is obvious, but the peasants were in little better position than Indian peasants. For they were burdened with high taxation and, inevitably under the circumstances, with debts which they had no hope of paying. This meant that it was a complete impossibility to invest in fertilisers, chemicals to fight pests, tractors and other farm machinery. It is not surprising that the peasants excluded such items from their thinking even when they knew such things were available had they had the resources to secure them. Thus modernisation today lags because of the prejudice of many of the smallholders.

In those stringent pre-war days there were only 620 ploughs to every 1,000 holdings, and of these no less than 182 were of such an ancient order that they merely scratched the surface of the soil. Incredible though it may seem, such ploughs were superseded in England in the days of the Anglo-Saxons! Of each 1,000 holdings, more than one-third had no plough of their own at all. Only 361 holdings per 1,000 possessed a harrow, 55 only boasted a roller, and only 44 possessed a seed drill. Tractors were virtually non-existent, and were to be seen, if at all, only in the more progressive regions of Slavonija and Slovenia. In fact, there was only one tractor to every 7,660 acres of arable land and one to every 7,160 acres of land devoted to crops.

Under such conditions it is not sur-

prising that it was impossible to produce enough to meet the costs of the peasant holdings. And the inadequately tilled and fertilised soil was used remorselessly, thus reducing its already meagre powers of production. It is a measure of the position that, in 1937, the average national income per person from agriculture was no more than 5d. a day. Yet so high was taxation and so large the debts of the farmers that many of the peasants were able to claim for themselves only a quarter of their income.

Effect of war

It was this primitive agriculture that was further enfeebled by the destructive impact of war. The enemy had practically obliterated the trifling industrial equipment which previously existed. More than half the farm equipment was destroyed, almost a quarter of the fruit trees and nearly two-fifths of the vineyards. The number of cattle had been reduced by more than a half and sheep and pigs by two-fifths. In addition, of the one-fifth of the houses destroyed, by far the larger proportion were in the countryside.

The situation was desperate enough, but the post-war population showed a rise of some 300,000 a year, thereby making even more urgent the need to increase food production. The Government immediately launched a programme of land reform. The 2,500 tractors in the possession of the large landowners were taken over and handed to the peasants. A national livestock pool was established and State model farms supplied large quantities of seed. In this way cultivation and cropping were made possible throughout the whole country.

Land-reform programme

The land, which had hitherto been in the hands of large landowners, joint stock companies, banks, churches and monasteries, plus all buildings, equipment and livestock, was taken over without compensation and shared amongst the peasants, the maximum holding being limited to 50 acres per family, or 75 acres if some of the land was woodland. This involved a State land pool of 3,800,000 acres, 2 millions of which were distributed to poor peasants. In this way 316,000 families were set up with land, buildings and equipment.

The rice field 'Zlatica', near Zrenjanin, Vojvodina. Much agricultural machinery is manufactured in this district. Other products include dairy products, sugar, molasses, etc.

All the debts of the peasants were cancelled, which relieved them of a collective burden of some £750 million, and a new system of taxation was introduced, which placed the principal burden of taxation on the better-off farmers.

The three pre-war agricultural schools were increased to over 40. In addition, a large number were established at the elementary level, in which a large number of pupils were given intensive training. Two agricultural faculties were set up in the universities as well as a faculty for forestry and one for agriculture.

The Government control of agriculture, however, proved a serious hindrance to progress. It can be said that the good resulting was that the cropping and delivery plans for agricultural products did ensure the basic requirements of the supply of foodstuffs to the urban population. But its effects on production were almost catastrophic, for, by 1952, the increase on the overall pre-war figures amounted to no more than 2%.

Agriculture, therefore, was freed of Government control and a 10-year plan was introduced to be put into operation in 1953. Hopes for the plan are based on several factors, but chiefly upon the development which has taken place in industry. This has made available more consumer goods, which act as incentive to the rural population to increase production in order to increase their own buying power. Equally important is the provision of artificial fertilisers, plant protection products and all the constructional materials that farming requires.

Industrial production

Whereas agricultural production has virtually remained stable, partly because of two severe post-war droughts, industrial production is now more than twice the pre-war figure. Electrical power is 400% above the 1939 level, and the production of agricultural machinery and chemicals needed in the industry are about 300% higher than in 1939. Thus the plan was put in hand with agricultural machinery and equipment at a higher level than ever before in the country's history, and with the certainty that the flow of these items would increase steadily for an indefinite period.

Although it is true that agricultural production has been disappointing in the post-war period, one change is encouraging. More production has been achieved with 17% less of the population working in agriculture than before the war. The three-quarters before the war has now been reduced to less than three-fifths, and this means that the whole of the Yugoslav economy has achieved a much better balance.

Paprika growers at Horgos, Vojvodina, near the Hungarian border

Necessity for increased production

It is, however, imperative for the country to step up food production, not only to increase the standard of living, but to ensure that the larger population is adequately fed. Already the leap in the population calls for a further 260,000 tons of cereals, 28,000 tons of meat and 11,000 tons of fat a year. Yet the markets are receiving little more of these commodities than they did in 1938. Thus Yugoslavia, very much an agricultural country and without any reserves of foreign exchange, has been in the ironical position of having to import, not only cereals and fats, but other agricultural products as well.

For such a country this is the highway to bankruptcy. Therefore the 10-year plan visualises an increase in wheat production of 20%, in sugar of 60%, of fats 25% and of meat 10%. It is also planned to increase milk production by 55%, eggs by 65%, vegetables by 50% and fruit by 90%.

Even if these increases are achieved, the Yugoslavs will eat only five eggs *per caput* compared with every 11 now eaten in England. The meat and fish consumption will only be 22 lb., as against 60 lb. now eaten in England and 65 lb. in Denmark. The fats consumption will be only 10 lb. to every 25 lb. now eaten in England.

The position in regard to processed foods is equally adverse. The consumption of sugar, for example, is less than half what it is in England and France. The agricultural production is insufficient to meet the needs of Yugoslavia's processing industries. In 1952 the food-processing industries were working at only 43% of their capacity. This means that there must be a considerable import of raw materials of all kinds, thus increasing the debit in the balance of payments.

Thus the need to increase agricultural production is a matter of economic life and death for the country. Exports of agricultural produce for the five years following the end of the war never rose to two-fifths of the pre-war figure. At the same time, food imports have continued to increase. Even when the effects of the two droughts between 1950 and 1953 have been discounted, imports were essential to keep the urban population from starvation.

Yet Yugoslavia has all the necessary conditions to a level where export of agricultural produce and processed foods on a large scale is a very definite possibility. The 10-year programme is but a first step towards the realisation of this vital aim, and it is being pursued with considerable energy.

Principal attention is being given to 'arable' production. This is natural in view of the fact that this basic form of agriculture conditions the development of livestock raising and accounts for one-half of the total production. As soil is of fundamental importance, particular attention is being given to maintaining and increasing fertility, which, in some regions, has fallen to a low level.

Untimely cultivation

Attention is also being directed to inferior and untimely cultivation. It is estimated that as much as three-tenths of production is lost in this way, and that the crops are often poor as the result of a lack of proper attention. The manuring of crops and an unremitting war on plant pests and diseases are being pursued to reduce the serious losses of potential crops which the country suffers year after year. These measures are also designed to increase the total crop, for the annual loss by mildew and smut amounts to some 450,000 tons of wheat, barley and oats.

In addition, arable farming is to be made much more efficient by a wider and more intelligent use of technical resources, including irrigation, chemicals and mechanisation, and the introduction of better types of plant. Measures against erosion are to be adopted, cultivation is to be much more extensive, and so is liming. A 5% increase in production is envisaged by the ploughing of marginal land and of some pastures. While the acreage under fodder crops and market-garden crops is to be increased, the acreage under cereals is to be curtailed. At the same time, so large are the opportunities for raising production by more rational and technical farming that the production of cereals is to be increased by 45%.

The use of chemicals on a scale unheard of in Yugoslavia is looked to as a means of increasing yields in the first period of the use of mixed farmyard manures and fertilisers. The use of farmyard manure is restricted by the number of animals carried per acre and is only one-quarter of the amount required. But this is being supplemented by no more than 6 lb. of artificial fertilisers per acre, an amount which is to be stepped up to 1 cwt. per acre in the period ending in 1963. (The official report adds: 'Such a rapid increase has certainly been rare in the annals of farmers anywhere in the world, but, though it will un-

questionably mean a tremendous impulse to Yugoslav agricultural production, the increase has been estimated on conservative lines and is well within the bounds of feasibility'.) The demand for artificial fertilisers is now in excess of that which the Yugoslav chemical industry can supply, but this will be met by an expansion of chemical production. The demand, too, will grow, particularly when it is seen that the use of fertilisers increases production by as much as $2\frac{1}{2}$ cwt. of wheat per acre.

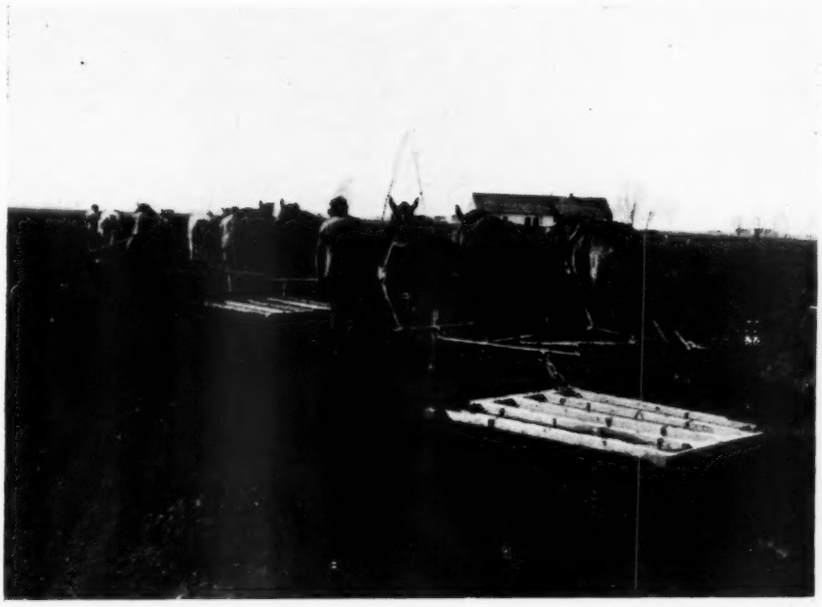
Irrigation

Irrigation, under the strain of two of the most serious droughts in the country's history, has been given a tremendous impetus. This is but one stage in a quartet which together will provide a sound basis for a new era in Yugoslav agriculture. Related to it are the draining of flood waters, the amplification of river regulations and the control of seasonal torrents. But irrigation comes first, for some $7\frac{1}{2}$ million acres of farm land would benefit by it. Because of the depressed state of the national economy, however, the irrigation of such a huge area of land is not immediately possible and the highest hopes are that half the total will be irrigated in the next 25 years. At the moment there are some 133,000 acres under irrigation and it is planned to increase this to $1\frac{1}{4}$ million acres in the next 10 years.

In drainage the plan is to concentrate on supplementing systems already in existence, although some new works are planned. To protect the land against floods it is planned to erect some 1,200 miles of river dykes, and at the same time it is the intention to protect some 3 million acres against erosion by torrential rains. These schemes together are estimated to cost about £2 million.

Increased mechanisation

Such schemes are of a national character, whereas the mechanisation of farming is more individual. Here, although the country has more machines than ever before, even when supplemented by draught animals, they are utterly inadequate to carry through the necessary field work within the time allowed. Thus each year there are losses ranging up to one-fifth of the crop, representing some 335,000 tons. The amount of money lost in this way is some £9 million per annum, which would buy sufficient combine harvesters to gather one-eighth of the total Yugoslav harvest.



Harrowing deep-ploughed soil at the co-operative 'Sonja Marinkovic', near Vrsac, Vojvodina

Increased mechanisation, however, along with a greater use of artificial fertilisers and better cropping methods, has resulted in an increase of 28 lb. of wheat per man-hour of labour. The increase on the peasant co-operatives is 16 lb. and in individual farming 14.75 lb. The 10-year plan is designed to provide a tractor to every 800 acres, a seed-drill to every 225 acres, a cultivator to every 340 acres, a combine harvester to every 1,720 acres, a maize harvester to every 3,150 acres and a trailer to every 75 acres. Thus it is planned to increase the number of tractors in use to 45,000, seed-drills to 81,000, combine harvesters to 4,000 and trailers to 80,000. Although this will still leave the Yugoslavs far behind in agricultural mechanisation when compared with other European countries, it is confidently expected that the difference will be obviated during the next 20 years.

Livestock

Livestock naturally suffered extensively during the German occupation of the country and it is to the credit of the Yugoslavs that they have restored the numbers to their pre-war levels. This is not the case with horses, but it is planned to reduce these even further as mechanisation makes these animals less necessary. Poultry are still 14% below the 1939 level, but pigs are 19% higher and sheep are 10% higher. Much remains to be done in this sphere and the 10-year plan not only aims at greater milk yields, and concentrating on breeds of cattle which furnish both milk and meat of high qualities, but on vastly expanding livestock numbers. It is intended to increase the number of cattle by close on $5\frac{1}{2}$ millions, or 113%. The prospective increase in sheep is 130%; pigs, 132%; poultry, 152%. If these figures are achieved the surplus amount of meat for sale in 1963 will be 280,000 tons, fats 100,000 tons, hides 40,000 tons and wool 16,000 tons. Happily, the principal fodder crops of hay and kale have shown already the expected increases and they promise to be adequate to meet the needs of the increasing number of animals.

The dairy system is to be radically improved. Some 1,700 new milk-collecting depots are to be built, and these will take over milk from the producer on a proper basis. Cooling and transport are to be brought up to date and 80 additional large-scale dairies are to be erected. These are to be supplemented by 50 smaller dairies for pasteurisation and distribution. These measures will eliminate losses in transport and handling, which

annually amount to 40,000 tons of dairy products.

Fruit- and wine-growing

Fruit-growing, which can play an important part in the country's economy, is at the moment seriously hindered by a shortage of young orchard stock of good quality. It is recognised that the whole fruit-growing organisation is unsatisfactory. Therefore what is proposed is virtually a fresh start. New orchards are to be developed, based on improved soil cultivation, better manuring, the re-grafting of trees where feasible and by new stocking. The introduction of better varieties of peaches, apricots, cherries and pears is expected to do much to improve production and the plan gives 4 millions as the number of new trees to be introduced in the next 10 years.

The practice previously followed has been to concentrate on standard trees, which adds to the difficulties of pruning, cropping and pest control. The new orchards, of which there are to be many, will be planted with half standard and half bush trees. Modern fruit-growing techniques are to be adopted, which will eliminate poor quality and sparse yields. Motorised sprayers and cultivators are to be used, anti-pest and -disease chemicals are to be employed on an adequate scale, and all the conditions essential to large-scale fruit production are to be adopted. At the same time attention is being given to the cooling of fruits as they come on to the market and to processing, sorting, packing and warehousing.

These last items are important, for large quantities of fruit are lost in Yugoslavia because of poor facilities for sorting, packing, drying and cooling. The lack of storehouses and cooling rooms is, in fact, serious. To meet the need it is proposed to build 1,700 centres with processing shops capable of handling a total of about 170,000 tons of fresh fruit and this should increase the productive capacity of the food industry by over 200,000 tons.

The vines are also in need of close and drastic attention. Most are too old and exhausted to produce grapes of acceptable quality. What is more, the vineyards abound in unsuitable varieties, often planted in low-lying areas inappropriate for vineyard cultivation. The production of new vines is very poor, nursery work is inadequate and the subsequent processing of grapes is far from satisfactory.

All these problems are being met. In future, vineyards, like orchards, will be large-scale. This will make it possible to organise bulk production with the use of the most up-to-date machines, something impossible in small-scale production. The plan is to spend some £80 million on the industry, thus securing an increase in production of 150% in grapes, currants, raisins and sultanas. The profit from the industry is expected to be about £75 million annually.

It will be seen that Yugoslavia is giving attention to every aspect of agriculture. In the 10 years covered by the plan, in fact, it is proposed to invest in the industry itself more than £2,000 million, a huge sum for a country with such a lean economy. In addition, it is proposed to invest something like £400 million in industries which supply farm tools and equipment, artificial fertilisers, plant control chemicals and food-processing industries of all kinds. Yet experts believe that the money will be realised from increased and superior production within four years of it being spent. For the sake of Europe and the Yugoslavs, it is to be hoped that these calculations prove to be correct.

Photos: Yugoslav Embassy, London

Applied Chemistry Congress

The First International Congress on Documentation of Applied Chemistry will be held in London from November 23 to 25, 1955. The congress, held under the patronage of the International Union of Pure and Applied Chemistry, is sponsored by the Society of Chemical Industry and has as president of honour The Rt. Hon. Lord Cherwell, C.H., F.R.S. The chairman of council is Sir William Ogg, M.A., PH.D., LL.D., director of Rothamsted Experimental Station.

An organising committee has been set up with Dr. Leslie H. Lampitt as chairman and Dr. Alexander King as deputy chairman. Dr. D. W. Kent-Jones is honorary treasurer and Lt.-Col. Francis J. Griffin is the honorary secretary.

Membership of the congress is open to all interested persons on payment of the membership fee of £2 2s. It is hoped to issue the detailed programme in the near future and all enquiries should be addressed to: The Honorary Secretary, International Congress on Documentation of Applied Chemistry, 56 Victoria Street, London, S.W.1.

Plough Disks for Argentina

It has been reported from Buenos Aires that Gebreuder Eberhardt Plugfabrik, a German firm, has received authority from the Argentine Government to set up a plant there, under the Argentine foreign investments law, to manufacture plough disks. The company will import installations and equipment valued at 352,000 trade dollars.

Spraying Techniques and Machinery in the Sudan Gezira

Continued from page 308

often be upset by the introduction of complicated machinery, resulting in increased time lost in breakdowns. This can very well apply when consideration is given to the simple method of applying a small volume of concentrated insecticide on a controlled swathe of 20 m. and the more complicated application involved in drift spraying. The former has given an 84% increase in output when applied commercially; the latter is unknown. It is, however, quite possible that the most economical and efficient method will be a compromise between the two techniques, using a swathe width of, say, 40 m., and also by so doing increasing the safety margin in flying the aircraft in what is a quite dangerous operation.

REFERENCES

1. Cowland, J. W., and Edwards, C. J.: *Bull. ent. Res.*, **40**, 83, 1949.
2. Snow, O. W., and Taylor, J.: *Bull. ent. Res.*, **43**, 479, 1952.
3. Joyce, R. J. V.: *Pl. Prot. Bull.*, **3**, Nos. 6, 7, 1955.

Photo: Plant Protection Ltd.

SIR HAROLD TEMPANY, C.M.G., C.B.E., D.Sc., F.R.I.C.

SIR HAROLD TEMPANY, Editor of WORLD CROPS from its foundation in 1949 until February 1955, died at his home in London on July 2 at the age of 73. He is survived by Lady Tempany.

Harold Augustine Tempany was born in 1881, the son of Thomas William Tempany. He was an outstanding authority on tropical agriculture and acquired his knowledge during the course of a long and distinguished career in the colonies.

Sir Harold retained many offices connected with colonial agriculture both before and after his retirement. In 1950 he was awarded a silver medal of the Royal Society of Arts.

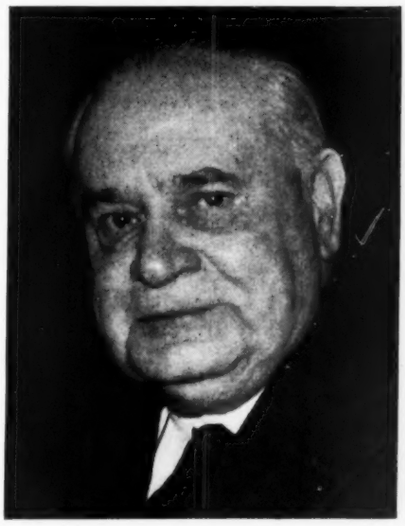
He was the author of many technical monographs and reports on tropical agriculture. His books include 'Principles of Tropical Agriculture' (with G. E. Mann), 'Soil Conservation Practice in the Colonial Empire,' and 'Agriculture in the West Indies.'

After his retirement Sir Harold was invited to become the first Editor of WORLD CROPS. A man of great knowledge and capabilities was in mind when the Editor was chosen and he fulfilled the requirements and more. It is often the case that when one retires one tends to lose contact with former work. Sir Harold was glad to accept the editorship for not only was he able to keep abreast of agricultural developments throughout the world but also he became, through the medium of the journal, more widely known.

Under his direct, clear-minded and pungently assertive editorship the journal flowered and has continued to flourish. We hope that it may serve to keep his memory alive.

Sir E. John Russell said in his introduction to the first issue of WORLD CROPS.

'Fortunately the house of Leonard Hill, already well experienced in technological matters, has undertaken the task of issuing this journal and, equally fortunately, Sir Harold Tempany, a high expert in crop production in the Colonies, has agreed to become its first editor.'



Sir William Ogg, M.A., PH.D. LL.D., Director of Rothamsted Experimental Station and President of the Society of Chemical Industry, although immersed in his duties at Rothamsted and in the preparations for the Annual General Meeting of the Society of Chemical Industry, telephoned his condolences and expressed a desire to be associated with the valedictory tributes paid to Sir Harold.

Mr. W. Leonard Hill, Chairman of Leonard Hill Ltd., writes:

After a life's work of endeavour, achievement and official reward, Tempany, 'full of years and honours,' had earned a quiet retirement, but his devotion to agricultural development overseas and the fact that he was used to carrying rather more than the burdens thrust upon the average man, brought him to us.

The transition from high-level official life (he had sat on legislative councils) to the editorial chair of a *proposed* journal with as yet no assistants or secretary must have been, at least, discouraging, but if that was so Tempany did not show it. He threw himself into the work with the greatest enthusiasm. His appreciation of the work of his colleagues brought him willing helpers.

There is no doubt that his influence on tropical agriculture and, perhaps even more, his ability as an editor were largely responsible for the fact that the paper he founded—WORLD CROPS—is now read and recognised throughout the world as the authority in its field.

More than once he expressed his admiration of the organisation he had chosen to join. Speaking for those in that company who worked with him, I say we were honoured by his presence among us. For his urbanity, his charm and the enthusiasm he transmitted we will always be grateful.

Mr. L. Lord, M.A., Assistant Agricultural Adviser, Colonial Office, London, writes:

HAROLD TEMPANY, whose death at the age of 73 occurred on July 2, had long and distinguished service in the agricultural branch of what is now known as H.M. Oversea Civil Service, finishing his official career as Agricultural Adviser to the Secretary of State for the Colonies.

Tempany, who was educated at the County School, Richmond, Surrey, and University College, London, was trained as a chemist and in 1903 was appointed Assistant Agricultural Chemist in the Leeward Islands, becoming Government Agricultural Chemist and Superintendent of Agriculture there in 1909. After serving as Director of Agriculture in Mauritius from 1917 to 1924, he received one of the most important Colonial directorships, that of Director of Agriculture, Straits Settlements and Federated Malay States, where he remained until 1936. He then became Assistant Agricultural Adviser to the Secretary of State for the Colonies. In 1940 he succeeded the late Sir Frank Stockdale as Agricultural Adviser and Vice-Chairman of the Colonial Advisory Council of Agriculture and Animal Health (later the Colonial Advisory Council of Agriculture, Animal Health and Forestry) and chairman of the Council's Standing Committee on Agriculture.

Throughout his career Tempany took a particular interest, both when overseas and in the Colonial Office, in research matters, for example in the development of the Sugarcane Research Station, Mauritius (now the Mauritius Sugar Industry Research Institute), whose work for the sugar industry of that island has been of such importance, and in the expansion of agricultural research in Malaya. As Agricultural Adviser to the Secretary of State for the Colonies he was one of the first to appreciate the need for greatly increased research on cocoa in West Africa in the very early stages of the swollen shoot virus disease, which has since devastated large areas of cocoa in the Gold Coast and Nigeria. In 1946, in company with Sir Frank Engledow and Prof. J. W. Munro, Tempany visited East Africa for the purpose of considering questions of agricultural research and in particular the future of the then East African Agricultural Research Institute at Amani. As a result of this visit the Institute was replaced by the East African Agriculture and Forestry Research Organisation near Nairobi in Kenya.

Tempany's valuable service to Colonial agriculture was given official recognition by the award of a C.B.E. in 1933, a C.M.G. in 1941 and a knighthood in 1946.

Tempany was a kind, considerate and patient man with an extensive knowledge of tropical agriculture and an exceptionally good memory. He had boundless energy and, after his retirement as Agricultural Adviser in 1946, took over the editorship of a series of books on tropical agriculture, published, with the active encouragement of the Colonial Agricultural Council, in London. At the time of his death he was completing a book on agriculture in Colonial territories for this series in which two books have already appeared, one on rice and one on cocoa. The editorship of this series and the preparation of his own book failed to fill his time and in 1949 he accepted the editorship of WORLD CROPS. His successful editorship of this journal he relinquished only shortly before his death.

Tempany will be remembered with respect and esteem by all who were associated with him.

Excessive Cultivation Can Reduce Grape Yields

C. G. FORSHEY*

Assistant Professor of Pomology, N.Y. State Agricultural Experiment Station, Poughkeepsie, New York

Prof. Forshey presents a case for the better management of vineyard soils; he considers that the use of the weed-killer o-sec.-butyldinitrophenol in conjunction with improved cultivation methods leads to increased grape yields. Deep ploughing should not be undertaken in any circumstances.

IT is a well-established fact that the physical structure of the soil markedly affects the growth of plants. The major ways in which soil structure exerts its influence are as follows:

1. Good soil structure permits rapid and deep penetration of incident precipitation and prevents or reduces run-off and surface evaporation. With a given amount of rainfall, this provides the maximum amount of moisture possible in the root zone of plants growing in that soil. It also greatly reduces soil erosion.

2. A porous, well-aggregated soil ensures ample soil aeration and supplies adequate oxygen for the chemical and microbiological reactions that are essential for a high level of soil fertility.

3. A well-aggregated soil is conducive to extensive root development.

Vineyards present a special problem in soil management. The vines are usually so closely planted and the plants are so sensitive to competition from other plants that it is impossible to incorporate many of the most effective soil-structure-improving practices into the vineyard soil-management programme. At the present time it appears impractical to grow grapes in combination with sod or summer cover crops.

Another factor that makes the vineyard soil-management problem unique is the fact that grapes occupy the soil for longer periods of time than any other crop grown in the Mid-West. Vineyards 50 years old or older are not unusual and 50 years of continuous cultivation usually results in almost complete breakdown of the natural structure of the soil.

Yield and air-space porosity

The fact that little attention has been devoted to vineyard soil structure in the past suggested that this might be a fertile field for investigation. It seemed plausible to assume that poor soil structure could be a possible contributing factor to the present low level of the state average yield of grapes in Ohio. This possibility was investigated in a study carried out in a number of commercial vineyards. Since 90% of the grapes grown in this state are of the Concord variety, this study was confined to Concord grapes. Sixteen vineyards were selected as being representative of the entire Ohio grape-growing industry. These vineyards were selected so as to provide a wide range in yield, a variety of soil types, different soil-management practices and locations throughout the state. Soil samples for physical analysis were collected in each of these vineyards at harvest in 1952 and in June, August, and at harvest in 1953. The percentage air space (porosity) of the soil was used as a measure of soil structure. The yield of fruit was accurately measured in each of these vineyards during the harvesting operation. The yields and the air-space porosity values of the soil samples taken at harvest, for both years, appear in Table 1.

The highly significant correlation between yield and air-space porosity in both years of the study indicates that the structure of the soil is an important factor in the production of high yields of Concord grapes. It is entirely possible that poor soil structure has been an important factor contributing to the decline in grape yields in this area in the past few years. This same conclusion was reached by Wander[1] in 1946.

In 1953 the correlation between yield and air-space porosity was statistically significant on each of the three sampling dates. However, the magni-

Fig. 1. Soil clod taken from the compact plough-sole layer in vineyard No. 15. (Note the flattened, compressed appearance of the roots)

*Formerly Research Assistant in the Department of Horticulture, Ohio Agricultural Experiment Station, Wooster, Ohio.

tude of the coefficient of correlation increased significantly as the season advanced. Since the water requirement of grapes increases as the fruit develops and approaches maturity, this is considered to be indirect evidence that the effect of soil structure on water relations of the soil is the most important influence exerted by this soil characteristic.

A number of factors affect the development and maintenance of soil structure. Among the most important of these are clay content of the soil, actively decomposing organic matter and cultivation. The effect of clay content is of theoretical importance only, because it cannot be changed in a given soil. The addition of readily decomposable organic materials to the soil is a very effective method of improving soil structure, but the limited availability of manure and other such materials makes this practice difficult, if not impossible, to follow. At the present time the only opportunity for addition of organic materials to the soil in many vineyards lies in the growth of a winter cover crop.

Cultivation effects

The effect of cultivation on soil structure can be helpful or it can be devastating. When the surface of the soil is crusted, cultivation will break up the crust into small aggregates. The size of the individual aggregates will depend on the moisture content of the soil at the time of cultivation, the tillage implement used and the severity of the cultivation. Repeated cultivation will gradually reduce the size of the aggregates until finally the surface of the soil is reduced to a fine, loose, single-grain condition. Such soil will tend to puddle badly when wet and, as a result, surface run-off becomes excessive and soil erosion becomes more severe. The fine soil particles tend to clog the large water-conducting pores of the soil and in this manner prevent rapid and deep penetration of rainfall. Since penetration of moisture is retarded under these circumstances, loss of water from surface evaporation is apt to be excessive. It is obvious, then, that good soil structure permits the most efficient usage of rainfall, whereas excessive cultivation destroys soil structure and prevents the most efficient utilisation of incident precipitation.

The soil management practices in effect in the vineyards included in this study appear in Table 2 along with the average yields of these vineyards for the two years of the study. It is apparent that the highest-yielding vineyards have not been subjected to cultivation practices as severe as those of some of the lower-yielding vineyards. The lower-yielding vineyards have generally been cultivated more times per season than the higher-yielding vineyards. The tillage implements used in these lower-yielding vineyards were generally more detrimental to soil structure than those employed in the higher-yielding vineyards. It is interesting to note that none of the seven highest-yielding vineyards was deep-ploughed (deep ploughing refers to the practice of ploughing a furrow between the rows) and only two of them were grape-hoed. Each of these vineyards averages 5 tons or more of grapes per acre for the two years, and this is indeed a profitable yield. The grape hoe was used in all nine of the lower-yielding vineyards and six of these vineyards were deep-ploughed. Deep ploughing is considered to be especially objectionable because of the root pruning that accompanies it and because of the compact plough sole that develops under this system of management. The effect on yield of the number of cultivations per season and of the different tillage implements used are summarised in Tables 3 and 4.

That the effect of excessive cultivation is not confined to the water relations of the soil is illustrated in Fig. 1. This depicts a condition that can, and usually does, develop in over-cultivated soils. This clod was taken from the plough-sole area in vineyard No. 15. Reference to Table 1 reveals the fact that the air-space porosity of the soil in this vineyard was only 3.81% in 1952 and 5.50% in 1953. These values are extremely low and indicate a very unsatisfactory physical condition of the soil. This vineyard has been subjected to the practice of deep ploughing for several years and the

TABLE 1

YIELD OF CONCORD GRAPES AND AIR-SPACE POROSITY† OF THE SOIL IN SIXTEEN REPRESENTATIVE OHIO VINEYARDS IN 1952 AND 1953

Vineyard No.	1952		1953	
	Yield, tons/acre	*Air-space porosity, %*	*Yield, tons/acre*	*Air-space porosity, %*
1	7.449	10.29	6.462	14.00
2	7.446	11.36	5.908	17.05
3	5.925	9.28	5.091	9.24
4	5.915	10.43	6.154	16.00
5	5.683	11.94	5.006	10.64
6	5.455	8.13	3.794	9.43
7	5.089	8.41	5.268	10.07
8	4.770	7.12	5.466	14.21
9	4.039	7.41	5.574	13.73
10	3.821	7.26	3.976	7.86
11	3.315	5.61	3.719	12.29
12	2.991	5.17	3.445	8.72
13	2.140	7.91	3.089	9.64
14	2.047	7.12	1.984	9.52
15	1.907	3.81	0.757	5.50
16	1.504	6.25	0.633	10.65
Correlation with yield:		0.800**		0.722**

† Unfilled pore spaces when a saturated soil is drained at a tension of 40 cm. of water.

** Statistically significant at the 1% level.

TABLE 2

NUMBER OF CULTIVATIONS PER SEASON, TILLAGE IMPLEMENTS USED AND AVERAGE YIELD OF CONCORD GRAPES OF SIXTEEN REPRESENTATIVE OHIO VINEYARDS FOR 1952 AND 1953

No. of vineyard	*Cultivations per season*	*Tillage implements used*	*Average yield* tons/acre*
1	1-4	Disc, grape hoe	6.955
2	1-4	Disc	6.673
4	None†	None	6.035
3	4-6	Disc	5.508
5	4-6	Disc, grape hoe	5.345
7	4-6	Disc	5.179
8	1-4	Disc	5.118
9	4-6	Disc, grape hoe, plough	4.807
6	6-8	Disc, grape hoe	4.625
10	6-8	Disc, grape hoe, plough	3.899
11	6-8	Disc, grape hoe, plough	3.517
12	6-8	Disc, grape hoe, plough	3.212
13	6-8	Disc, grape hoe	2.619
14	4-6	Disc, grape hoe, plough	2.016
15	4-6	Disc, grape hoe, plough	1.332
16	1-4	Disc, grape hoe	1.069

* Average of 1952 and 1953 yields.

† This vineyard mulched with wheat straw.

TABLE 3

EFFECT OF THE NUMBER OF CULTIVATIONS PER SEASON ON THE YIELD OF CONCORD GRAPES

No. of cultivations per season	*No. of vineyards*	*Average yield,* tons/acre*
None (mulch)	1	6.035
1-4	4	4.954
4-6	6	4.031
6-8	5	3.574

* Average of 1952 and 1953 yields.

Fig. 2. Weed control obtained through the use of 'dinitro' is better than is usually obtained by cultivation alone. Two of the vineyards included in the study received dinitro sprays during the two-year period and averaged 5.227 tons per acre

plough-sole layer has become quite compact. It can be seen in Fig. 1 that the larger roots are somewhat flattened and compressed. Root growth was confined to the cracks between such clods; there were no roots within the clods. A soil condition such as this retards development directly by difficulty of penetration as well as indirectly by restricting soil aeration in the rooting zone. A situation such as this provides a very unsatisfactory medium for plant growth. Fortunately, it appears that such situations can be developed only by excessive cultivation.

The evidence indicates that overcultivation might be responsible for the relatively poor soil structure of the lower-yielding vineyards in Ohio. Wander[1] concluded that excessive cultivation was responsible for the poor physical structure of the soil in the vineyards included in his study. He considered the physical condition of the soil to be a major factor in the decline of grape yields in Ohio. The results of this study are in perfect agreement with his work.

Chemical weed control

That grapes are sensitive to competition from other plants has already been mentioned. Therefore, good weed control is essential to the successful operation of the vineyard. However, in view of the fact that excessive cultivation appears to be detrimental, some supplement to, or substitute for, cultivation seems to be indicated. A chemical weedkiller could certainly be used to advantage. Of all the compounds that have been tested in the vineyard, dinitro ortho secondary butyl phenol (*o-sec.*-butyldinitrophenol) has been most satisfactory. This compound provides good weed control at low cost without injury to the vines.

TABLE 4
EFFECT OF TILLAGE IMPLEMENTS USED ON THE YIELD OF CONCORD GRAPES

Tillage implements	*No. of vineyard*	*Average yield,* tons/acre*
None (mulch) ..	1	6.035
Disc	4	5.619
Disc, grape hoe ..	5	4.123
Disc, grape hoe, plough	6	3.313

* Average of 1952 and 1953 yields.

Its use is now a standard practice in some of the better vineyards. Application of 'dinitro' weedkiller in the vineyard is recommended by the Ohio Agricultural Experiment Station[2] and the New York State Agricultural Experiment Station.[3] In view of the evidence presented here, it appears that cultivation of vineyards should be kept to a minimum and dinitro sprays should be used as a supplement to cultivation (see Fig. 2).

As mentioned above, deep ploughing of vineyards is especially objectionable and should not be practised under any circumstances. DDT is so effective in controlling grapeberry moth that ridging of the soil in the row is no longer necessary and it is certainly not desirable. In addition to subjecting the soil to needless cultivation, the grape hoe, which is universally used for this ridging, frequently inflicts serious mechanical injury to the vines. (The grape-hoeing operation is sometimes described as snap, crackle and pop in reference to the shallow roots that are severed by this practice.) Experience in Ohio has indicated that, after the winter crop is worked into the soil in the spring, three or four light cultivations with a disk are adequate under most conditions. Weeds in the row are then controlled with two or three sprays of dinitro. The recommended rate of application is 2 pints of 55% dinitro ortho secondary butyl phenol (Dow General), 10 gal. of diesel fuel oil and water to make 100 gal. This spray mixture is applied at the rate of 50 to 100 gal. per acre, depending on the number and size of weeds.

Continued on page 330

Irrigation by the Spray-Line System

J. S. STOWER

British Overhead Irrigation Ltd.

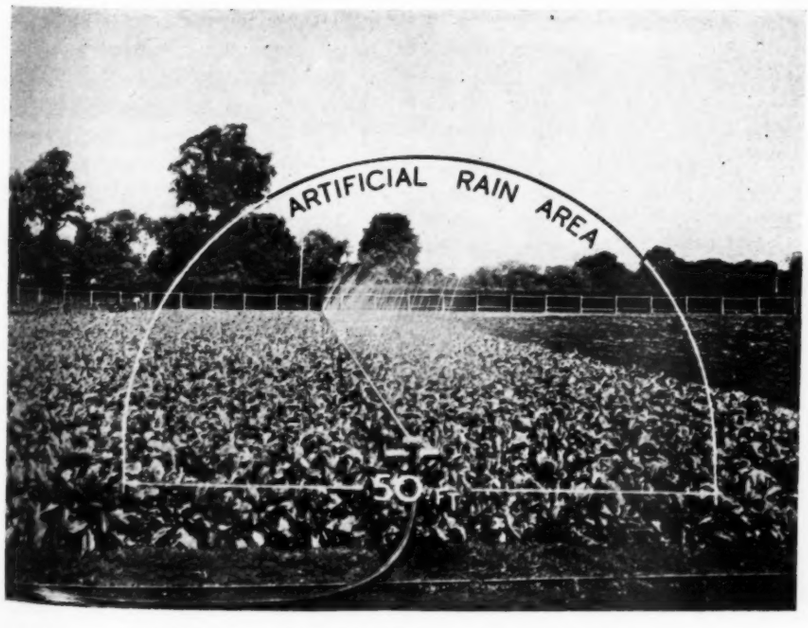
In Britain orchards require approximately 2 in. of rain per month to obtain maximum yield. Any deficiency must be made up by artificial means. As artificial watering is an additional expense, but, nevertheless, an essential to profitable growing, it is advisable to use artificial rain equipment in the most economical and efficient manner. Moreover, artificial watering must simulate natural rain, falling in a finely atomised and even spray—not as a heavy shower, which will form puddles—so that the soil can quickly absorb the moisture.

A POTENTIAL user of irrigation equipment has to consider whether a sprinkler that waters in circles or one that waters rectangular strips of ground will best suit his purpose.

Waste water

Sprinklers which water circular areas of ground must inevitably overlap, sometimes as much as 70% of the ground covered. This means that 70% of the ground will be watered at least twice and part of the 70% even three times at the places where four circles meet. Water is a valuable commodity and cannot afford to be wasted; unnecessary watering means that more horse-power is used, which increases running costs, apart from the damage that might result from over-watering. Some of the research stations in England have carried out intensive experiments since the war in connection with irrigation. One of them recently published a leaflet on drop sizes from sprinkler sprays and in it stated that droplets larger than 2 mm. have the effect of damaging the soil structure by sheer weight of water. The results which followed this were a hard-panned surface on bare soil which prevented air and moisture reaching the roots. The large rotary-type sprinkler is designed to cover an extensive area of ground and this involves a large jet at a central point through which a heavy stream of water is ejected. The droplets from this type of spray are sometimes as large as 4-6 mm. The spray line, on the other hand, ejects the water through great numbers of small nozzles spaced along its entire length and the droplets do not exceed 2 mm. in size.

For large-scale farm crops, sugar cane, pasture, etc., overlapping can be tolerated, but for the vegetable and flower grower and, in fact, for any grower producing comparatively valuable row crops in an intensively cultivated plot, irrigation equipment that waters rectangles and one that throws an atomised spray is by far the best choice.



A B.O.I.L. oscillating sprayline watering growing crops.

Spray-line system

The spray-line system of watering consists of sections of piping, generally made of light alloy aluminium tubes in 16 ft. 6 in. units. Each unit is joined together by a ' quick-action ' coupling and lengths up to 450 ft. can be used. A standard 16 ft. 6 in. spray-line unit is fitted with nine spray jets in a straight line. The jets are small and have the effect of atomising the spray and throwing it to a maximum distance of 30 ft. At the beginning of the length of spray line a machine known as an oscillator is fixed which slowly turns the whole line from side to side. It operates entirely by the water pressure. Thus, in a length of 450 ft. of spray line, there are 243 jets. The spray covers a width along its entire length of 50-60 ft. (30 ft. both sides) and a total area of ½

(Left) *The B.O.I.L. 'Wizard' oscillator.* (Right) *A B.O.I.L. oscillating sprayline in action in the vegetable gardens of Windsor Castle*

acre. It can be easily and quickly moved to new positions so that, by rotation, one line can be made to cover large areas of ground.

The soil is like a sponge and will only absorb water at a slow rate. When watering is carried out at a fast rate much of the water runs to drainage and the heavy weight of water and large droplets tend to upset the soil structure on the upper layer; subsequently a crust is formed which prevents penetration of water and stops air reaching the roots. This applies particularly to bare soil or to soil on which row crops are spaced out. It does not apply to the same extent to ground where the crops are close together or where they entirely cover the soil, as with grass.

Mains systems

In vegetable farms or farms where crops suitable for spray-line irrigation are produced, a system of mains must be put in or portable mains can be used if preferred. If a permanent main is put in, it is customary to lay it below ground level and to fit standpipes at intervals of 100 ft. The standpipes consist of a riser with a screw-down-type valve to which a 30-ft. length of rubber hose is used to connect the water supply to the spray line. On large farms a principal supply main to feed the lateral standpipe main from source of supply must be installed, and the size of the mains and capacity of the pump, if a pump is to be used, must be carefully worked out by the irrigation firm responsible for the installation.

Spray lines are generally made in two sizes, namely, 1¼ in. and 1½ in. in external diameter. The smaller size is intended for lengths not exceeding 300 ft. and the larger sizes for lengths exceeding 300 ft. Various different sizes of jets can be fitted according to the climate, the nature of the crops to be watered and the precipitation required. The largest jets fitted in a line 450 ft. in length will require a total volume of water of 3,540 gal. per hour, working on a maintained working pressure of 40 lb. per sq. in., and will put down the rain equivalent of ⅓ in. per hour on an area of ½ acre, in a fine, even spray that will not damage the most delicate seedlings.

Working arrangement

The setting up of a spray line is simple and quick and can be carried out by one man. Each 16 ft. 6 in. unit requires a support. There are various different types for different requirements; tripod, spike or trestle are the most common types in use, and each type can be provided with telescopic devices if required. The supports are placed in position and the units are carried along the row and one placed near each support. On the return journey the man joins each unit together by means of the 'quick-action' couplings, connects the rubber hose and turns on the water. It is advisable to have a spare set of supports so that these can be set up in readiness for the move, and in this way sometimes several units can be carried over and laid on the spare supports without uncoupling. Moving the spray lines can be greatly speeded up by this method. Some growers use an entire spare set of spray lines, so that when a new position is to be watered the only thing to be done is to move the connecting rubber hose from one spray line to the other. The spray line thus put out of operation is then left until the ground on the surface is dry enough for men to walk about without sinking into the soft earth.

Excessive Cultivation Can Reduce Grape Yields

Continued from page 328

The first application should be made in May, when the weeds reach 6 to 8 in. in height, with repeat applications at three- to four-week intervals.

A programme such as this provides effective weed control, prevents mechanical injury to the vines by eliminating cultivation with the most injurious tillage implements, and helps to preserve the structure of the soil, thereby permitting the most efficient utilisation of rainfall.

This article is published with the permission of the Editor of *Down to Earth.*

REFERENCES

1. Wander, I. W.: *Bull. Ohio agric. Exp. Sta.*, p. 633, 1946.
2. Hill, R. G., and Alban, E. K.: *Fm. Home Res.*, 39, No. 286, 1954.
3. Shaulis, Nelson, and Dugan, D. R.: *Cornell Ext. Bull.*, p. 816. 1951.

WORLD CROPS

OUR NEXT ISSUE will feature several aspects of **forestry**, and will also include a report on the agricultural equipment exhibited at this year's **Royal Show**, together with other articles and the usual features.

Australian Agricultural News

From our Australian Correspondent

Wheat situation

At the beginning of the 1953-54 marketing season stocks of old-crop wheat in Australia totalled about 38 million bushels. Added to the harvest for that year, these large stocks raised the total supply available for disposal during the season to more than 235 million bushels—the highest since 1949-50. In the course of the season, however, only about 140 million bushels were actually sold, compared with 174 millions the previous season, when the supply was 24 million bushels less. Domestic consumption remained fairly stable, with 34 million bushels going into consumption as flour, 18 million bushels being sold for stock feed and 17 million bushels for other purposes. Exports dropped sharply during the season, reaching only 67½ million bushels, as against 102 million bushels in 1952-53.

By the beginning of the current season wheat and flour stocks had increased to about 95 million bushels. This was the highest peace-time figure on record, only being exceeded during the war years, when 154 million bushels were on hand at the end of the 1942-43 season.

Surplus

The chairman of the Australian Wheat Board has already estimated that potential sales during the current season would just about absorb the new crop being delivered. In other words, the probable carry-over would be approximately the same size as on November 30, 1954 (95 million bushels). This estimate was based on the assumption that Australian wheat exports would increase by about 16 million bushels in the 1954-55 marketing year. Clearly, if current higher crop forecasts are realised, exports must increase by a corresponding amount to maintain end-of-season stocks at at least the same level as November 30, 1954.

Even taking the most optimistic view of the current international situation, it appears that Australia will be faced with the problem of maintaining abnormal stocks of wheat for some time ahead. As early as April of last year the Commonwealth Government announced that it would assist State storage authorities to provide additional storage facilities by guaranteeing a Commonwealth Bank advance to the Australian Wheat Board of £3½ million for expenditure on projects approved by the Board. By January of this year more than £2.7 million had been expended on supplementary storage accommodation. Of this total, approximately £1.1 million was for New South Wales, £837,000 for Victoria, £504,000 for West Australia, £202,000 for South Australia and £42,000 for Queensland.

Stabilisation scheme

Australian wheat is now being marketed under the terms of a new five-year stabilisation scheme, which provides that during the five crop years 1953-54 to 1957-58 wheat will be made available for home consumption at stable prices, and growers will be guaranteed a return equal to cost of production on exports of up to 100 million bushels from each of the five harvests. In the first instance the guarantee will be met from a stabilisation fund established by means of an export tax collected at the maximum rate of 1s. 6d. per bushel. Should this fund prove inadequate, the guarantee will be met from Commonwealth revenue.

So far as export marketing arrangements are concerned, Australia is still one of the four exporting countries with quotas under the International Wheat Agreement (I.W.A.), which was renewed for a three-year period in 1953. Under the agreement provision was made for guaranteed sales and purchases at the beginning of the 1953-54 wheat year of 11,462,000 tons (421,156,404 bushels). Australia's quota at the time was 1,306,346 metric tons (48 million bushels). After further adjustments, however, Australia's quota was reduced to 1,207,170 tons (44,355,905 bushels). This was further adjusted until Australia's quota was steadied at 1 219,137 tons (44,795,616 bushels).

During the 1953-54 season, however, Australia sold only about 28 million bushels, representing 64% of her I.W.A. quota. Up to December 31 of this season sales were proceeding at a much faster rate, transactions totalling 34.5 million bushels having been recorded against the Australian quota.

Under the domestic marketing provisions of the new five-year stabilisation plan, all wheat for consumption in Australia during the crop years 1953-54 to 1957-58 will be sold at a basic price of 14s. a bushel, bulk, f.o.r. ports. This is subject to the proviso that the I.W.A. price at the beginning of the Australian marketing season is not less than 14s., in which case the I.W.A. price becomes the effective selling price. But in no case will the selling price be lower than the assessed cost of production.

Stable cost index

Because there has been no movement in the cost index, the price guaranteed by the Commonwealth for up to 100 million bushels of wheat exports from the 1954-55 crop remains at 12s. 7d. Last December and in early January Australian export wheat was selling at a basic price of 14s. 6d. per bushel. While export prices remain at this level practically all the excess over 12s. 7d. per bushel will be paid into the new Wheat Prices Stabilisation Fund.

The first advance to growers on wheat from the 1954-55 harvest was fixed at 10s. 4d. per bushel, bulk, and 10s. 8d., bagged, subject to deduction of freight from growers' sidings to the nearest terminal port. West Australian growers again received an initial premium of 2d. per bushel because of their freight advantage in relation to the principal oversea markets for wheat. Both advances were 4d. per bushel higher than those established for the 1953-54 crop. When announcing them the Acting Minister for Commerce and Agriculture stated that a first payment at this level was possible because of the acceptance by the Commonwealth Government, all States and the wheat industry of the wheat stabilisation plan. Without the stabilisation plan it would have been necessary to determine the rate of the first advance on a purely commercial basis and it would have necessarily been more conservative.

South African Agricultural Developments

From our South African Correspondent

THE Governor of Southern Rhodesia said that Southern Rhodesia's tobacco crop for 1954-55 was the second biggest in the history of the territory's tobacco industry. Opening the 1955 tobacco sales, he said the completed official estimate for the crop was just under 110 million lb.

Kaffir-corn

In South Africa the 1953-54 kaffir-corn crop is estimated at 2,271,000 bags of 200 lb. each—1,411,000 bags on European farms and 860,000 bags on native farms in the reserves, according to a revised estimate by the Division of Economics and Markets. Taking this estimate as a basis, the 1954-55 crop is estimated at 907,000 bags on European farms and 740,000 bags on native farms in the reserves.

Maize

The 1954-55 maize crop has been estimated at 38,791,000 bags of 200 lb. each by the Division of Economics and Markets. The estimate is based on reports received at the beginning of March. According to a revised estimate, last season's crop totalled 38,857,000 bags. Production figures for the Cape are 2,967,000 bags.

Various factors must be studied by the National Marketing Council—which reports on the Maize Board's recommendation on the new season's price for maize—and by the Minister of Agriculture, who makes the final decision. One factor is production costs. The other is the increasing areas in which farmers are planting maize and the problem of vast surpluses which the railways cannot move, but which weevils and beetles may infest. Most items in production costs have risen slightly in the past year, except fertiliser and seed. But any rise in yield reduces the cost. The yield used in the calculations is the average for the past five seasons. This year that average should be exceptionally high.

Four of the past five summer crops have been bumper crops. This higher yield may cancel out any rise in farming costs and the same price as last year was hoped for. That price included an incentive bonus of 1s. 6d. a bag to encourage farmers to grow more maize. The railways have cut drastically the amount of maize that can be exported during the autumn and winter months. Meanwhile, farmers have put more land under maize this summer than in last year's record plantings. They have reduced their sunflower, teff, kaffir-corn and bean plantings to concentrate on maize. The Maize Industry Control Board then decided to fix this year's net price for the best grades of maize at 30s. a bag, a drop of 1s. The Board said that it had recommended to the Minister of Agriculture that the price to producers during the forthcoming season be fixed at 30s. 3d. a bag for the best grades. The Minister has since indicated that the Government has agreed to this price provided producers contributed 3d. a bag to the Stabilisation Fund by means of a levy. The Board accepted this proposal, so that the net price is 30s. a bag. This reduction in the price of maize will help to reduce costs in producing eggs, bacon, milk, butter and cheese.

Sugar

The South African sugar industry produced 275,000 tons of sugar more in the 1954-55 season than it did in the first season after the war ended in 1945, Mr. G. G. N. Perk, of the Sugar Milling Research Institute, Durban, told the annual conference of the South African Sugar Technologists' Association in Durban. The output this season was 828,555 tons—a record—compared with 553,074 tons in 1945-46. This season's production was 103,000 tons more than the previous record in 1953-54. Two factories made more than 100,000 tons of sugar each. Darnall produced 102,165 tons and Tongaat 101,800 tons. The sugar came from a crop of 7,374,241 tons of cane—also a record. Mr. Perk said the crushing had been done by 17 factories, working 36½ weeks, compared with 30½ weeks two seasons before.

Seeds

The West German Government have authorised the buying of £25,000 worth of seed in South Africa. The chief of the Division of Horticulture in the Department of Agriculture told the annual conference of the South African Seedsmen's Association that lupin, pea and bean seed would form the main bulk of the purchase.

Oranges

The biggest crop of oranges South Africa has ever known is expected this winter. The South African Citrus Exchange expects 300,000 to 400,000 more 70-lb. export cases of citrus this year than last, when the export itself was a record. The total crop is likely to reach 6,750,000 cases. New citrus orchards coming into production are the main cause of the increase, which will tax to the utmost the export shipping facilities. The principal citrus-growing districts have had good rains, and these have had beneficial effects on size and quality of the crop.

Basutoland dam

The British Government's plan to dam the Orange River in one of the deep gorges in Basutoland could have important results in food production in South Africa, but no final steps will be taken until the whole position has been carefully considered, especially in consultation with the Union Government, which is vitally interested in this matter.

A deep dam in Basutoland could provide adequate water supplies to make the Great Fish River valley the biggest irrigation area in South Africa. If that was not considered desirable, the irrigation settlements on the lower Orange River could be increased to at least four times their present size. No official reports have yet been made on the project, but it is known that the report of the South African engineering company responsible for the initial survey was so encouraging that the British Government asked the famous British firm of Sir William Halcrow and Partners to investigate. This task was completed some time ago, but the substance of their report has not yet become available.

Arley Fabrications Ltd.

We have been informed that the address of Arley Fabrications Ltd. is 107 Lancaster Street, Birmingham 4 and not Manchester as announced in our June issue.

S.C.I. Agriculture Group

Two meetings of the Agriculture Group of the Society of Chemical Industry were held recently in the rooms of the Chemical Society, Burlington House, London. At the earlier meeting a paper was read by Dr. C. Bloomfield on ' Leaf Leachates as a Factor in Pedogenesis.' In the absence of the Group Chairman, Dr. G. W. Cooke was in the Chair.

Dr. Bloomfield said that the phenomena of iron reduction and migration, which are characteristic of grey and podsolised soils, are generally regarded as being caused by the action of the humose upper horizons normally present in these soils. In his paper he gave the results of an investigation of the properties of water extracts of unhumified plant debris. From the results of this work Dr. Bloomfield showed that the relatively simple organic compounds present in such extracts are a much more important factor than is colloidal humus in causing migration of sesquioxides and clay.

At the next meeting two papers dealing with current fertiliser practice were read.

In the absence of the Group Chairman, Dr. G. W. Cooke took the Chair until Mr. Church had given his paper. Prof. Wallace then took the Chair for the remainder of the meeting.

The first paper, ' Recent Aspects of Fertiliser Practice,' was presented by Mr. B. M. Church of Rothamsted Experimental Station.

The present manuring of cereals in England and Wales was examined on the basis of information collected in fertiliser practice surveys since 1950. These surveys provide data for districts throughout the country and, in particular, for the eastern counties, where current information on manuring had been lacking for many years. Regional differences, and the influence on average cereal manuring of previous cropping, the varieties grown, and other factors were considered. Attention was drawn to the need for further experimental work to determine the most profitable fertiliser dressings under these varied conditions. In addition to estimates of average manuring, the range of fertiliser dressings to individual cereal fields was indicated, and the additional profit per acre which might be obtained by farmers whose cereal manuring is very different from the economic optimum was estimated.

In presenting the second paper, ' Present Fertiliser Practice and Future Possibilities,' Dr. G. W. Cooke of Rothamsted Experimental Station emphasised that his paper was really a very lengthy opening of the discussion on Mr. Church's paper.

The present manuring of common English crops, as determined by the Survey of Fertiliser Practice, was examined with particular reference to the amounts of fertilisers which might profitably be used. In general, cash crops were manured more rationally than fodder crops. In many districts the amount of nitrogen fertiliser used for cereals was grossly inadequate. Extra quantities of nitrogen could be used on grassland to extend the grazing season and to intensify production. The obstacles to increased use of fertilisers for a variety of crops were examined.

' Malastan '

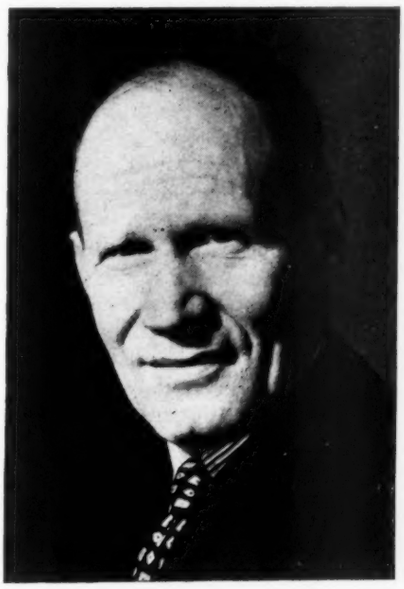
Trials were carried out against leaf-hoppers in Great Britain recently, using ' Malastan ' fog solution, one of the malathion formulations manufactured by the Standardised Disinfectants Co. Ltd. Promising results were obtained. The ' Swingfog ' machine was used to apply the insecticide.

Agricultural Engineers' Association

Mr. D. P. Ransome, managing director of E. H. Bentall and Co. Ltd., Maldon, Essex, has been elected President of the Agricultural Engineers' Association. He is also President of the Institution of British Agricultural Engineers, which creates a unique situation in that he holds concurrently both the professional and trade premier positions in the industry.

Mr. Ransome is also a trade representative of the Manufacturers of Agricultural Machinery appointed to the British Standards Institution and has done considerable work on the British Standards Institution Agricultural Machinery and Implements Industry Standards Committee.

He is intensely concerned with colonial agricultural development and has done much to encourage the use of modern methods for coffee and plantation machinery in the colonies, and also the development and marketing of internal-combustion engine valves, of which Bentall's is one of the leading world manufacturers.



Mr. D. P. Ransome

NEW BOOKS

Vegetation and Watershed Management

By E. A. Colman. Pp. xv + 412, illustrated. New York: The Ronald Press Co. $7.00.

This book is concerned with the problem of obtaining the maximum yield of usable water from a catchment basin, so it is written with the demands of the irrigation and the municipal water engineer in mind. The author is a forester who has worked in the research department of the California Forest and Range Experiment Station, so has an admirable background for the task he has set himself.

The book is divided into three sections. The first discusses briefly the concept of the water yield of a catchment basin and the problems of regulating the flow of water, so that the yield is as uniform as possible throughout the year, and also the quality of the water, so that it contains as little silt as possible. The second part deals in general terms with the methods available for water control, and the third part illustrates these with special reference to the various regions of the U.S.A. The book throughout is addressed to the general reader rather than to the specialist, for rarely is any quantitative data given to help one judge how effective, or how costly, any method of control is likely to be. Further, it is almost exclusively concerned with American work and American conditions, but this is largely a reflection of the fact that so much of the work has been done there.

As the title indicates, the author is primarily concerned with the effect of vegetation on water yield, either through its ability to increase the intake of rain into the soil and hence into the ground water, or else through its use of water by transpiration; and in several places he discusses the possibility of minimising transpiration losses by a suitable choice of vegetation or method of management. He points out, however, that most of the suggested methods for doing this have only been tried out on small catchment areas for short periods of time, so that much more work must be done before they can safely be applied to large areas. He also discusses adequately the validity of some of the standard phrases one so often hears about the alleged benefits that forests in general, or a particular type of forest practice, has on the water yield.

The treatment of the subject is accurate and the general principles are sufficiently clearly enunciated for the intelligent reader to be able to form his own opinion about the chances of a given method being of appreciable help in his particular conditions. It is, however, slightly repetitive in style and many of the interesting and important points made are not very clearly brought out.

E. W. Russell

Food and Agriculture in Britain, 1939-45

By R. J. Hammond. Pp. xii + 246. Stanford, California: Stanford University Press. 40s. net.

This book is not a history of food production and control, but a critical analysis of the mass of information on the subject to be found in official records.

The main functions of the Ministry of Food were to procure the main foods, to supervise their distribution and to control their prices. The author considers that the rationing system was effective in checking the evils of maldistribution, but many plans for controlling production and movement of foods were less happy. He points to examples: potatoes, which defied all planning, consistently impelling the Ministry to expensive, if successful, improvisations; the White Fish Zoning Scheme, which attempted to economise in the wasteful transport of fish; the large-scale experiment in carrot and onion distribution; and the handling of eggs. He outlines the Ministry's attitude toward these and other problems, reflects on their benefits and defects, and assesses their contribution to the war effort.

Mr. Hammond is justified in devoting a chapter to milk, not only because of its importance as a food, but because the Ministry reorganised milk marketing in England and Wales on lines laid down by the Government before the war, in spite of the fact that these permanent changes in the industry might have been challenged in the courts as *ultra vires* the Defence Regulations, which conferred emergency powers on Government only in so far as they were necessary to the prosecution of the war.

The Ministry of Food developed in most unexpected directions, and these activities are recorded and evaluated by the author. Thus it was prevailed upon to organise communal feeding; to accept responsibility for a series of price adjustments that bore no relation to the requirements of food control, but were governed by Treasury insistence that the cost-of-living index must not be allowed to rise; and to reduce the claims of food on labour and transport. Again, while food control was not intended as an instrument for promoting better feeding, the Ministry became involved in nutritional surveys, provision of milk to mothers and children and in procuring and distributing vitamins.

Post-war restrictions are treated with great judgment. 'A country denuded of foreign assets, both dollar and non-dollar, requiring to make good the capital equipment destroyed or wasted during six years of war, to increase exports that had fallen to below one-third of the pre-war level up to one and a half times that level—such a country could not afford to dispense abruptly with the restrictions, or the artificial stimuli, that control of food and agriculture had provided.' To this was added the conviction that a world food shortage would follow an armistice. The Government was also committed to maintain welfare measures and the improvement of the national diet.

Post-war control was therefore inevitable, but it was unfortunate that the Ministry should become involved in the controversy between those who advocated bulk purchase and would perpetuate the Ministry of Food, and the opposing party who claimed that food shortage could be cured by a return to private enterprise. These problems have, in great measure, resolved themselves; the Ministry has gone and the author is led to assess the achievement of the Government in war-time food and agriculture policy. He shows how complete was Government control of home food production and the degree of success attained. 'Looked at in retrospect, the

war effort of British agriculture, reflected in output no less than in acreage figures, takes on the aspect of a triumphal procession, with a hint of impeccable organisation that such a procession always conveys. By a combination of increased home production with conservation measures, regulation of distribution, and changes in dietary pattern, it proved possible to sustain the nation in health and efficiency on greatly reduced imports '. The author concludes: ' We should acknowledge and take advantage of the incidental benefits that control helped to confer, whether upon the state of nutrition of the poor or the state of repair of the nation's agriculture; we should deny to control itself, and as a whole, any merit beyond that of necessary evil. Only by such rigour in sifting out the less necessary tasks of the Welfare State will it be possible to keep efficient the discharge of those tasks that all would now agree are essential '. A fitting conclusion from an author who writes of aspects of war-time control, sometimes with humour, often critically, always from his intimate knowledge of the subject.

D. H. GRIST

Cocoa

By D. H. Urquhart. Pp. xix + 230, illustrated. London: Longmans. 1955. 35s.

Mr. Urquhart has undertaken the much-needed but formidable task of writing a book on cacao. Since Van Hall's revised edition of ' Cacao ' in 1932 there has been no publication attempting to cover all the important aspects of this crop. It is particularly appropriate that Mr. Urquhart's book, ' Cocoa ', is published now and, as stated in the foreword by Sir Geoffrey Clay, that it should be written primarily as a handbook for planters.

In spite of the very considerable amount of research work on cacao since the early 1930s it is a fact that there are lamentably few published results from field experiments. And it is these results that would be of particular interest to those wishing to expand the area under this crop today. There is little information available anywhere in the world concerning the influence on cacao growth and yield of variety, spacing, manuring, shade and cultivation. In making the brick it is therefore necessary to use every piece of straw. Unfortunately, the author has not availed himself of certain published results of significance, to quote only the omission of the yield data at varying age of trees and densities in Nigeria compiled by Russell and published in the *Empire Journal of Experimental Agriculture*, or the extremely interesting results of shade and fertiliser interactions in Trinidad. On the other hand, Mr. Urquhart has included much valuable information on the preparation and grading of cacao beans for market, and on pests and diseases. These chapters will be greatly appreciated by those responsible for building up a cacao industry in new countries or of maintaining production in the old.

Certain chapters of the book—The Botany of Cocoa, Cocoa Soils, Rehabilitation of Cocoa Plantations in Trinidad, Virus Diseases of Cocoa—have been prepared by recognised experts on those subjects. The book would have benefited had the author also expressed his views on these subjects, since he has had the unique opportunity of studying cacao in so many different territories. A stronger connecting link between these chapters and those written by Mr. Urquhart would have been an advantage. For example, on the question of fertilisers, which is uppermost in many planters' minds, the book gives little help. That there is need for fertilisers in Trinidad is clear from the chapters on Cocoa Soils and on Rehabilitation of Cocoa Plantations. Indeed, under certain circumstances fertiliser is provided free in that island, but exactly what the fertilisers are is not recorded and the reader is left to wonder whether the dressing of 60 lb. of ammonium sulphate, 33 lb. of superphosphate and 19 lb. of potassium sulphate mentioned on p. 34 is that actually distributed to planters. Ceylon is noted as using artificial manure, but no details are given. Malaya, where fertilisers are generally necessary for cacao, is not mentioned. Moreover, the planter will look in vain in the chapter 'Botany of Cocoa' for the commonplace varietal terms ' West African amelonado ' and ' Upper Amazon'.

The technique of rooting cuttings is very fully described—13 pages of text, two of diagrams and 10 of photographs—but many planters confronted with an acute shortage of clonal material would welcome more information than that given in the one short paragraph on budding. The three pages of text on nursery seedlings (pp. 44-46) are concise and will be found useful. But surely good seed should give not 80% germination, but 100%.

To the book there are six appendixes, some of which seem to have been added as afterthoughts. Appendix II, ' Costs of Cocoa Culture on Estates and Peasant Farms', will be particularly interesting to those who are considering whether to embark on cacao growing. The other appendixes include a table on spacing and densities per acre, a note on the preparation of bordeaux mixture, further information on the preparation of rooted cuttings, a description of soil surveys and a highly technical report on recent research into cacao fermentation.

' Cocoa ' is lavishly provided with magnificent photographs. Indeed, it may well be that many will gain more information from the 97 black and white and the 10 colour prints than from the text itself.

O. J. VOELCKER

Tanganyika Agricultural Corporation

The Colonial Office has announced that the Tanganyika Agricultural Corporation, which is to continue the work of the Overseas Food Corporation, came into being on March 30, 1955. It will work in the areas taken over from the Overseas Food Corporation, and will be financed for this purpose until September 1957 by a Colonial Development and Welfare grant from Her Majesty's Government.

The new Corporation will also be invited by the Government of Tanganyika to assist in carrying on the Rufiji Basin reconnaissance survey which is at present in progress under the aegis of the Food and Agricultural Organisation of the United Nations. In particular, it will be asked to establish the trial farms that are being planned as part of this investigation. In addition, consideration is being given to other agricultural development projects which might with advantage be undertaken by the Corporation by agreement with the Government.

FARM MACHINERY

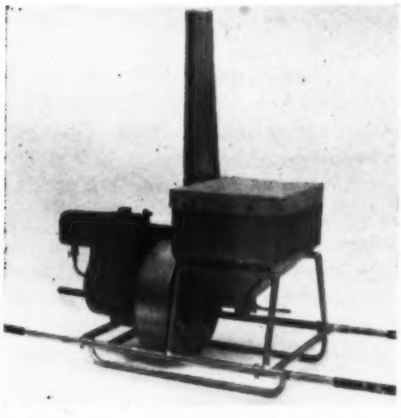
Power Dusting Machine

The new ' Kestrel ' power duster is a machine that should create a good deal of interest amongst agriculturists, both in regard to design and performance.

It is light enough to be carried over the most difficult terrain by two operators or pushed on wheels by one on a well-pathed estate. It can, of course, be carried on any vehicle. Another feature is the fact that there are no wearing parts on any part of the machine other than the engine. The life is therefore at least as long as any petrol motor engine; all parts are renewable.

The fan is very advanced in design and pivots entirely independent of the impeller; it is therefore easily directed to deliver powder into the air, towards the ground, right or left and to a certain degree forwards or backwards. It will dust with equal efficiency the tallest rubber and coconut trees, fruit trees and bushes, tea, rice, cotton and any root crops. The hopper holds 40 lb. of sulphur powder and other powders according to density. When carried on a vehicle a hopper can be fitted to take a much larger amount. The feed is operated by a mechanised agitator and can be instantly adjusted to supply from nothing to 20 lb. per minute.

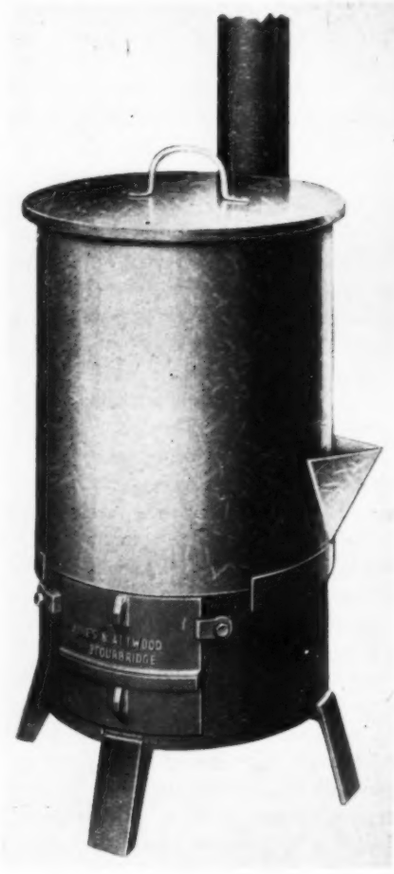
The ' Kestrel ' machine is light in weight, but robust in construction, and is throughout a thorough engineering job.



The 'Kestrel' power dusting machine was used during the dusting season on a rubber plantation. Labour requirements were cut by half and dusting was carried out four days per week instead of six days. The 'Kestrel' is light and portable; it can be carried over bunds and even through rice itself

Small-Scale Soil Steriliser

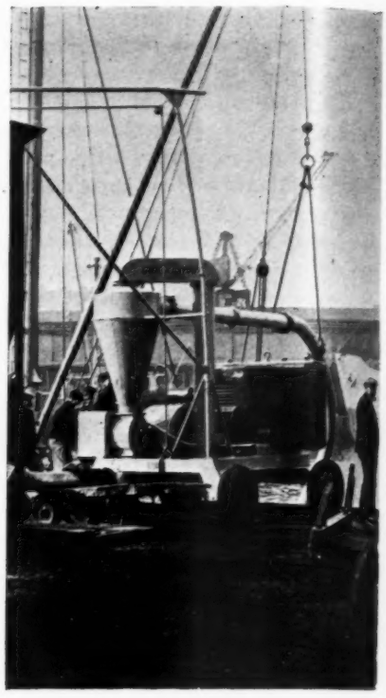
The production of a new small-scale steam soil steriliser has been announced by Jones and Attwood Ltd. This apparatus is used to control wire- and eelworms, to kill weed seeds and to control all root infections and damping off.



The small-scale 'Sterilatum'

The machine consists of a strong galvanised steel tank with a false bottom, underneath which is a shallow water tank of large area placed directly on top of a large specially designed fire box. When steam is generated it passes upwards round the edge of and through holes in the false bottom and under the edges of a semicircular steam duct, permeating the soil above it.

A strong cast-iron chimney with a cowl is supplied and the elbow at the foot of the chimney is provided with a soot door. A permanent tundish is fitted for filling the water tank and checking the water level.



The first of three 'GrainVayors' to be installed on the premises of John Cook and Son Ltd., Aberdeen

This machine is designed to treat $1\frac{1}{3}$ cu. ft. or approximately 100 lb. of soil.

C. C. Wakefield & Co. Ltd.

C. C. Wakefield & Co. Ltd., makers of Agricastrol Tractor Oils, announce the appointment to their Board of Directors of Leonard G. Packham.

Mr. Packham joined the company 30 years ago and became Overseas General Manager, a position he continues to hold.

Pneumatic Grain Conveyor

Conveyors (Ready - Built) Ltd., Gloucestershire, are now manufacturing, under licence from the Myers Sherman Co., Illinois, U.S.A., a mobile pneumatic grain conveyor. They have called it the ' Grain-Vayor '.

The unit is suitable for working from dockside to the mill, from craft to lorries or weighing-off hoppers, from barges to wheeled vehicles or sheds, etc. The arrangement of flexible piping and intake nozzles makes it particularly suitable for these purposes; the machine can be moved and dismantled quickly. It is of robust construction and is just over two tons in

Optional equipment for general spraying purposes includes a large-capacity, adjustable spray gun, suction hose with strainer, overflow hose and 25 ft. of discharge hose complete with fittings

weight, thus allowing it to be lifted on to ships for the discharge of cargo into receivers on the quayside.

The capacity, which is dependent on the length of suction and delivery pipe, is 800-1,000 bushels/hour, based on a total conveying length of 50 ft. The maximum conveying distance is 250 ft.

The machine is powered by a Lister FR6-type cold-starting diesel engine, which develops 54 h.p. at 1,800 r.p.m.; the air turbine is of the impeller multi-stage type mounted on self-aligning sealed bearings and the material being handled by-passes the turbine and goes through a high-efficiency cyclone on the suction side, the material being transferred to the delivery side through a rotary discharge lock, which is driven at slow speed from a countershaft, which in turn is driven from the main engine p.t.-o.

All pipes, bends and cyclones, although light in weight for ease in handling and portability, are constructed from high-tensile abrasion-resisting steel. The diameter of the suction and discharge pipes is maintained at 8 in. throughout for ease in interchangeability.

All-Purpose Pump Kit

The new John Bean (John Bean Division, Food Machinery and Chemical Corpn., Lansing-4, Mich., U.S.A.) all-purpose pump kit converts a tractor to a high-pressure spray rig. It is the first unit to offer sapphire-hard, diamond-honed pump cylinders. The two-cylinder, plunger-type pump (the John Bean ' Royalette ') delivers up to 400-lb. pressure at 7 gal. per min. The sapphire cylinders are so hard that abrasive materials, such as whitewash, will not wear them. Self-expanding plunger cups, sliding over the glass-smooth cylinders, have prolonged life and seldom need replacement. The pump is totally enclosed and oil-bath lubricated.

The all-purpose pump is mounted direct on to the tractor's p.t.-o. shaft. A relief valve with a 400-lb. diaphragm pressure-gauge and an air chamber are attached with a bracket to the tractor fender. Also included in the basic kit is a quick-acting cut-off valve that can be mounted wherever convenient for the tractor operator.

Multi-Wire Reeler

The multi-wire reeler, which will be placed on the market shortly, has been developed by The Harvest Saver and Implement Co. Ltd. The reeler is easily operated and enables one, two or three wires to be ' paid out ' simultaneously and in the same time required for one wire. The employment of three wires for sheep is strongly advocated as an insurance against jumping—the cost of the extra wire is negligible. The reeler is made in two sizes to accommodate either one, two or three wires.

The illustration shows the manner and ease in which the multi-wire reeler is operated. Note the hook attached to the home-made harness

WORLD CROP REPORTS

INTERNATIONAL

Sugar

United Kingdom.—Conditions in this country are at last improving and field work is going ahead at full swing. It has been unfortunate this year that, with a plentiful labour supply available, work should have been held up to such an extent due to the weather. A heavy growth of weeds is reported from all areas and there is much leeway to be made up in clearing the fields. To June 4, 40% of the crop had been singled, compared with 60% to the corresponding date last year and 77% to the comparable date in 1953.

So far as pests and diseases are concerned, more blackleg, a malady affecting plant stems, has been experienced than usual. Mangle fly attacks have been reported, but little mention has been made of aphis this year. This is partly due to the heavy rain, which destroyed the eggs and young flies early in the season, and also, of course, to the smallness of the plants for the time of year.

The final acreage this year will probably be slightly down on 1954, although there will not be much in it.

First estimates suggest that a crop somewhat below average will be outturned.

Pakistan.—A report from the North-West Frontier Province states that the sugar-cane crop in that region has sustained considerable damage due to attacks of pyrilla. Cane varieties normally yielding up to 12% of sugar are producing no more than 8.4%, as the canes have completely dried up. The Government is making certain concessions in the way of local charges in order to ameliorate growers' losses to some extent.

Jamaica.—It appears probable that last season's record sugar crop of 363,303 tons will be exceeded this year. The latest estimate of the Sugar Manufacturers' Association (of Jamaica) Ltd. made on May 31, 1955, puts the 1955 crop at 382,367 tons.

Hawaii. — Sugar production to March 27 last amounted to 195,014 short tons, as against 194,270 short tons to the comparable date last year, according to *Sugar*. Final output closed last year at 1,077,354 short (961,923 long) tons.

Guadeloupe.—Sugar production for the current season is estimated at 110,000 to 120,000 tons, according to Licht. In some areas there have been complaints that the cane is suffering from drought, but, to a certain extent, this has brought the compensating advantage of a higher sucrose content.

Germany (West).—Sowing this year was held back by the inclement conditions and it was not until the second half of April that drilling could be completed. Germination was then retarded due to the cold weather experienced during May. Conditions are best in the Rhineland and Southern Germany, where thinning has mostly been completed by now, according to Licht. In Schleswig-Holstein and Lower Saxony it is still under way.

There have been considerable complaints this year of root-blight and wire-worms.

Progress of the crop is considerably behindhand in many districts and crop prospects are not promising.

The planted area is 263,000 hectares, against 256,110 hectares in 1955.

Czarnikow Rev.

ENGLAND AND WALES

Agricultural report.—Agricultural conditions in England and Wales on June 1, 1955, have been summarised by the Ministry of Agriculture, Fisheries and Food. Corn crops are rather backward owing to the cold weather, but improved towards the end of the month. Potatoes and other root crops are also less forward than usual. Pastures made little growth until the weather became warmer.

The weather during May was generally cold, wet and changeable. High winds occurred in the first week, causing damage in some eastern areas. During the second week cold air spread over the country, bringing widespread ground frosts and snow in many parts; heavy rain was also experienced. Mainly bright weather, but with showers from time to time, followed in the third week and continued until the last three days of the month, when the weather became warm and sunny.

Corn crops.—Winter wheat is generally satisfactory, although cold weather has retarded growth. Spring wheat improved during the month, but is rather backward.

Winter barley is rather backward, but is improving. Spring barley is satisfactory on the whole, but cold weather has retarded growth; loss of colour is reported from several districts.

Winter oats are generally satisfactory, although rather backward. Spring oats were slow to make growth, but improved towards the end of the month; crops are generally healthy.

Rye is making satisfactory progress.

Beans for stockfeeding. Winter beans have recovered from earlier frost damage and are healthy but backward. Spring beans germinated well, but growth has been slow.

Peas are less forward than usual owing to late sowing and cold weather; germination has been satisfactory on the whole and crops are healthy.

Potatoes.—Early potatoes are less forward than usual owing to late planting and cold weather; frost damage is reported from several districts. Maincrop potatoes were planted later than usual and it is too early to report on the condition of the crop. A small proportion remained to be planted in a few areas at the end of the month.

Roots.—Turnips and Swedes. Reports from most districts indicate that only small areas have been sown. In the few areas where better progress has been made germination and growth are reported to be slow.

Mangolds. In most areas the sowing of mangolds is almost complete. On the whole, germination has been slow and in many districts irregular.

Sugar beet.—The sowing of sugar beet is virtually complete. Reports from many areas indicate that germination is uneven and growth slow. Some damage by ' blowing ' occurred in East Anglia, necessitating redrilling.

Fodder beet.—The sowing of fodder beet was completed in most areas. Germination and growth were slow.

Kale.—In many districts the sowing of kale is not yet complete. Early sowings have been rather slow to germinate, but damage by flea beetle is negligible so far.